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Zooplankton Community Dynamics and Water Quality of Polecat Creek, Coles County, Illinois, Spring, 1975

Carl Edward Baird
Eastern Illinois University

ZOOPLANKTON COMMUNITY DYNAMICS AND WATER QUALITY OF POLECAT

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CARL EDWARD BAIRD

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ZOOPLANKTON COMMUNITY DYNAMICS AND WATER QUALITY OF POLECAT CREEK, COLES COUNTY, ILLINOIS, SPRING, 1975.

I. INTRODUCTION

The health of an aquatic environment is dependent upon the constitution and interaction of many physical, chemical, and biological forces. Changes in the physical and chemical components of a lake or stream can affect the biological productivity of that water. The level of enrichment in a small stream is partially the result of drainage of dissolved nutrients and eroded particulate matter from field run-off and domestic sewage. The increased load of materials may represent the major contributing source of these materials to a downstream lake and may result in an accelerated rate of eutrophication of such lakes.

The impounding of Polecat Creek has been suggested by the Regional Planning Commission of Coles County (Reid et al., 1972) as one of the alternatives for increasing the water supply for Charleston, Illinois. The site of the dam for this reservoir would be approximately midway between Ashmore, Illinois, and mouth of the stream (Fig. 1, Appendix, p. 164). One of the main criteria for selecting a reservoir site is the prediction of its future as a useful water resource. Three aspects of such a prediction are (1) the rate of sedimentation, (2) the rate of eutrophication, and (3) the future biological productivity of the impoundment. This study considers the zooplankton portion of biological productivity as influenced by several physical and chemical factors. The purposes of this study are to describe the ecology of the zooplankton community and the water quality of Polecat Creek and to predict faunal changes which might result from the impoundment of the stream.

II. DESCRIPTION OF POLECAT CREEK

Polecat Creek (Fig. 1) is a small stream in central Illinois, originating from fields tiles in N. W. $\frac{1}{4}$, Sec. 26, T. 13 N., R. 13 W., Edgar County, flowing westward for about 22.3 kilometers to its juction with the Embarras River in N. E. $\frac{1}{4}$, Sec. 8, T. 12 N., R. 10E., Coles County. From source to mouth the stream has a drop in elevation of 40 meters. East of Ashmore, Illinois, the stream flows through Flanagan-Raub-Drummer soil associations while Strawn-Lawson soil associations characterize the remainder of its course (U. S. D. A., 1968). The water shed for the entire stream system drains 7434 hectares of land (S. C. S. Office, Charleston, Illinois).

Open, cultivated fields characterize the 14.5 kilometer portion of Polecat Creek which lies east of Ashmore, Illinois. This portion of the stream experiences a 15.3 meter drop in elevation at a rate of 1.06 meters per kilometer. Polecat then receives enrichment from the septic tank run-off and outlet of raw sewage as its flows through three quarry ponds, south of Ashmore (Fig. 1). The remainder of the stream experiences a 24.7 meter drop in elevation over a 7.6 kilometer distance, at a rate of 3.25 meters per kilometer. The calculated time required for water to travel from the quarry ponds to the mouth of the stream was an average of 3.4 hours with a range of 2.0 to 6.2 hours.

The high, local relief of the lower portion of Polecat allows only limited field cultivation adjacent to the stream. Most of the banks are tree-lined or forested. Cattle feed lots and pastures are common, sometimes permitting the animals to enter the water. The portion one to four kilometers from the mouth is characterized by its rapid flow rate, bottom of sand, rocks, gravel, or bedrock, and bluffs of shale rock. The stream slows down considerably as it approaches its junction with the Embarras River. The low, local relief near the mouth allows for the formation of many back-water pools. When heavy rain raises the water level of the Embarras River, the last 200 meters of Polecat Creek and its adjacent backwaters become inundated and movement of water in this area almost ceases.

III. LOCATION AND DESCRIPTION OF SAMPLING SITES

<u>Site 1</u>: N. E. $\frac{1}{4}$, Sec. 8, T. 12 N., R. 10 E., approximately 125 meters from the mouth of the stream. Forest area adjacent to the north bank and cattle pasture adjacent to the south bank. Bottom of sand. Average depth, 56 centimeters; average width, 13 meters. Mean velocity, .46 meter per second.

Site 2: N. E. $\frac{1}{4}$, Sec. 9, T. 12 N., R. 10 E., approximately 1.9 kilometers from the mouth of the stream and 29 meters east of a stone bridge. Empty pasture adjacent to the north bank and forest area adjacent to the south bank. Bottom of coarse gravel and small rocks. Average depth, 48 centimeters; average widith, six meters. Mean velocity, .90 meter per second.

Site 3: N. E. $\frac{1}{4}$, Sec. 2, T. 12 N., R. 10 E., approximately 4.9 kilometers from the mouth of the stream and 27 meters east of the bridge. Cattle pasture adjacent to the north bank and empty pasture area adjacent to the south bank. Bottom of coarse gravel, small rocks, and boulders which were often covered with mats of the alga, *Cladophora*. Average depth, 44 centimeters; average width, 4.5 meters. Mean velocity, .74 meter per second.

Site 4: N. E. $\frac{1}{4}$. Sec. 1, T. 12 N., R. 10 E., approximately 7.2 kilometers from the mouth of the stream. The site is represented by an old quarry pond through which the stream flows. Cattle pasture adjacent to the north bank and an area of trees adjacent to the south bank. Bottom of fine silt and mud. Average depth between two and three meters; largest dimension across the pond is about 110 meters. Negligible velocity.

Site 5: N. W. $\frac{1}{4}$, Sec. 6, T. 12 N., R. 11 E., approximately 7.4 kilometers from the mouth of the stream and 24 meters east of a stone bridge. Cultivated field adjacent to the north bank and forest area adjacent to the south bank. Bottom of coarse gravel, large rocks, and boulders which were covered with a thin layer of algae, silt, and debris. Average depth, 35 centimeters; average depth, 35 centimeters; average width, 6.5 meters. Mean velocity, .51 meter per second.

Site 6: N.W. $\frac{1}{4}$, Sec. 6, T. 12 N., R. 11 E., approximately 7.6 kilometers from the mouth of the stream, 34 meters from the outlet of the largest quarry pond (Lake Ashmore) south of Ashmore, Illinois, and 210 meters upstream from Site 5. Forest and residential areas adjacent to the north bank and brush and forest areas adjacent to the south bank. Bottom of rocks, gravel, deep mud mixed with dead vegetation and detritus. Average depth, 42 centimeters; average width, six meters. Mean velocity, .46 meter per second.

IV. FIELD METHODS AND PROCEDURES (Appendix, p. 136)

V. LABORATORY METHODS AND PROCEDURES (Appendix, p. 144)

VI. RESULTS

A. Water Quality:

Table 1 summarizes the water quality data for this study.

Dissolved oxygen:

Dissolved oxygen levels were above 10 milligrams per liter during February, March, and most of April (Fig. 2). Thereafter, oxygen levels dropped to between seven and 11 milligrams per liter. One high measurement of 15.5 milligrams per liter was taken at Site 3 on April 11. The standard deviation values in Table 1 indicate little variation of oxygen levels among sampling sites.

Nitrogen nitrate:

The nitrogen nitrate levels varied between 15.6 and 38.5 milligrams per liter for the entire section of the stream (Table 1). There was little variation among the mean values for each respective site, all averaging about 25 milligrams per liter. The levels dipped to a lower level during March and the first weeks of April (Fig. 3). From the last portion of April to the first weeks of May the levels rose again. Using standard deviation as a measure of variation (Table 1), Sites 1 and 6 showed the least amount while Site 2 showed the greatest amount of variation among the weekly samples.

Soluble (ortho-) phosphate:

Phosphate levels never exceeded four milligrams per liter at any of the six sampling sites (Table 1). The highest phosphate levels were found at Sites 4 - 6, while Sites 1 - 3 exhibited lower levels (Fig. 4). There were some rare instances of a gradual, downstream decrease of soluble phosphate for a given sampling date. The mean values for each respective sampling site show this tendency to a small degree (Table 1). Site 5 exhibited the greatest variation for weekly phosphate levels.

Total and calcium hardness:

Total hardness ranged from 140 to 300 milligrams per liter $CaCO_3$ for the lower 7.6 kilometers of Polecat Creek (Table 1). There was only a 10 milligram difference between the highest and lowest mean values for total hardness. Figure 5 shows some evidence for change in total hardness from one site to another on any single collection date. Note the abrupt change in total and calcium hardness levels from Sites 1 - 3 to Sites 4 - 6 on May 30 (Fig. 5). The sampling of Sites 4 - 6, for that date, was performed during and immediately after a 4.06 centimeter rainfall (Fig. 10) whereas Sites 1 - 3 were sampled prior to such.

Calcium hardness levels ranged from 100 to 250 milligrams per liter $CaCO_3$. The difference between the mean values for calcium hardness was five milligrams. Standard deviation values show that calcium hardness varied more at Sites 1 and 2 than at any other site (Table 1).

Suds occurring on the surface:

Small amounts of suds were a common occurrence throughout the study at Sites 1 - 4. Occasionally the impoundment at Site 4 had great accumulations of suds near its shores.

<u>Hydrogen ion concentration (pH)</u>:

The pH values for the lower 7.6 kilometers of the stream ranged from 6.9 to 9.0, but averaged 7.9 (Table 1). During any single sampling date, there was very little variation of pH values among the six sampling sites (Fig. 6).

<u>Stream velocity</u>:

Figure 7 shows that the downstream sites (1 - 3) usually had the highest velocity values on any given sampling date. Site 2 had the highest single measurement, 1.8 meters per second, on March 28. At Site 1 the current almost ceased on three occassions (February 28, May 23, and 30). This cessation of flow happened when the Embarras River (Fig. 1) reached flood stage and caused Polecat Creek to backup several hundred meters from its mouth.

Bare rocks and coarse gravel characterized the stream bed at Site 2, which also had the highest mean velocity (.90 m./ sec.) (Table 1). The second highest mean velocity (.74 m./ sec.) occurred at Site 3. The bottom material at this site consisted of stones and medium-sized gravel mixed with sand and some silt. The substrate usually had some covering of algal slimes or mats of the alga <u>Cladophora</u>. Site 5 had the third highest mean velocity value (.51 m./ sec.) and had a substrate similar to that found at Site 3 but was more heavily covered with algal slimes and silt. Sites 1 and 6 had identical mean velocities (.46 m./ sec.) but had totally different substrates. Site 1 had a substrate of almost pure sand with small deposits of silt near the banks. Site 6 had a spongy substrate of detritus, mud, stones, and gravel. Figure 7 also shows that any weekly change in the current velocity was felt to some degree at all sampling sites.

Turbidity:

The turbidity levels for Polecat Creek were erratic. Usually the levels for all sites were well under 100 F.T.U., but peaked up to and beyond 500 F.T.U. several times (Fig. 8). Standard deviation values (Table 1) show that Sites 1, 4, and 6 exhibited the greatest variation in turbidity while the least was shown by Sites 2, 3, and 5. A comparison of Figures 8 and 10 reveal that the very pronounced peaks of turbidity occurred during or a few days following rainfall. The above mentioned peaks of turbidity occurred on February 28, March 28, April 25, May 9 and 30, June 6 and 13. An examination of the qualitative data (Tables 3 - 8) reveals that 11 species appeared only during one or more of the above dates of high turbidity. These 11 species were *Brachionus havanaensis*, *Platyias patulus*, *Ceriodaphnia lacustris*, *Kurzia latissima*, *Moina affinis*, *M. brachiata*, *M. micrura*, *Polyphemus pediculus*, *Ectocyclops phaleratus*, *Mesocyclops edax*, and *Orthocyclops modestus*.

Air and water temperature:

The water temperature never dropped to freezing during the dates of sampling, although air temperature did fall to 0° C. on March 14 (Fig. 9). Air and water temperatures usually fluctuated together and increased through the duration of the study.

B. Zooplankton community:

From the examination of 99 qualitative and 33 quantitative, replicate samples 17,019 organisms were identified and enumerated. The total collections yielded the identification of 21 genera and 18 species of Rotifera, 14 genera and 20 species of Cladocera, 9 genera and 9 species of Copepoda, and four different forms Ostracoda (Table 2). The members of Ostracoda could not be identified since formalin preservation had rendered their valves closed which prevented identification by the Sedgwick-Rafter method. Besides the Ostracoda, two nonloricate Rotifera and two Copepoda could not be identified. These organisms are illustrated as Unknown 1 - 8 in Figures 11 - 13. The purpose of these illustrations is to provide a means of accounting for organisms which were repeatedly encountered but could not be identified. Also, these illustrations may be useful as reference for any future study which involves these same forms.

Table 2 summarizes all the qualitative and quantitative data by indicating the number of weekly collections which contained a specific zooplankter at each respective sampling site. The percent frequency occurrence values for each weekly sample are listed for the qualitative and quantitative collections in Tables 3 - 8 and 9 - 11, respectively. Figures 14 - 22 illustrate the periodicity of dominance within the four major taxa (Rotifera, Cladocera, Copepoda, and Ostracoda) and the overall, predominant zooplankter for each weekly collection.

Taxonomic listing and periodicity description:

All the organisms which were encountered during this study are taxonomically listed below. It is felt that periodicity descriptions of only the more abundant organisms will provide a more lucid and less complicated picture of the major forces affecting the community dynamics of the zooplankton. Therefore, with a few exceptions, only those taxa which achieved dominance in Figures 14 - 22 have their periodicity described below their listing.

Phylum: Rotifera (Classification after Edmondson, 1959)

Class: Bdelloidea

Order: Bdelloida

Family: Philodinidae

Philodina sp. Ehrenberg

Remarks. - This nonloricate rotifer generally occurred in low numbers except at Site 4 on April 18 when it composed 20.4 percent of the 217 total (Table 6). This peak was the only time when *Philodina* sp. was the dominant rotifer in any of the qualitative collections (Fig. 17). Quantitative data show this genus as the dominant rotifer at Site 1 on May 30 and June 6, and the predominant zooplankter on April 25 (Fig. 20). The April 25 occurrence of Philodina sp. as the predominant form at Site 1 was very unusual since Brachionus calyciflorus was the predominant form in all other collections at all sites, for that date.

Rotaria neptunia (Ehrenberg)
Rotaria sp. Scopoli

Class: Monogononta

Order: Ploima

Family: Brachionidae

Subfamily: Brachioninae

Brachionus angularis Gosse

Brachionus bidentata Anderson

Remarks. - This species occurred below Site 4 in only four collection (Table 2). The first appearance of the species was May 2, but shortly thereafter qualitative collections revealed its dominance at Sites 3 - 6 (Figs. 16 - 19). Predominant zooplankter ranking was found at Sites 3, 4, and 6 during the end of May in qualitative and quantitative collections.

Brachionus budapestenesis Daday
Brachionus calyciflorus Pallas

Remarks. - The qualitative collections revealed this rotifer present in about half of the samples from Sites 1 - 3, but it occurred, with only one exception, in every sample at Sites 4 - 6 (Table 2). Tables 3 - 11 show that B. calyciflorus experienced a very dramatic increase of frequency occurrence during April and the first of May. Sites 4 - 6 commonly had 50 to 70 percent of the zooplankton made up by this species during this time period. The time span of dominance and predominance expression was confined between March 21 and April 16 in all collected samples, after which percentages diminished greatly (Figs. 14 - 22).

Brachionus caudatus Barrois and Daday

Brachionus havanaensis Rousselet

Brachionus quadridentatus Hermann

Remarks. - Qualitative data indicate that the first appearance of this species was April 25, but dominance was not achieved until May 30 (Table 8 and Fig. 17). This rotifer was the predominant zooplankter on May 30, comprizing 23.6 percent of the 270 total at Site 5 (Table 7). Quantitative data also show a peak around May 30 (Tables 9 - 11). B. quadridentatus was, with one exception, absent from Sites 1 - 3 (Table 2).

Brachionus rubens Ehrenberg

Brachionus urceolaris Müller

Remarks. - This rotifer was the predominant zooplankter form in a majority of the qualitative collections taken between February 21 and March 14 (Figs. 14 - 19). Many of the frequency occurrence values exceeded 50 percent with the highest percentages occurring on February 28 (Table 3 - 8). After March 14, the frequency of B. urceolaris diminished and was rarely seen during the remainder of the study.

Euchlanis sp. Ehrenberg

Remarks. - Euchlanis sp. occurred rarely until it became more numerous in late April and May (Tables 3 - 8). On May 23 it composed 17.2, 11.1, and 3.8 percent of the zooplankton at Sites 4, 5, and 6 respectively, but never achieved dominance in any of the collections.

Keratella cochlearis Gosse

Remarks. - This small rotifer was very infrequently encountered but was present at all sites.

Keratella quadrata Müller

Keratella valga Ehrenberg

Remarks. - Keratella valga occurred only infrequently at Sites 1 - 3 and was totally absent from Sites 4 - 6 in all samples (Table 2).

Macrochaetus sp. Perty

Mytilina sp. Bory de St. Vincent

Notholca striata Müller

Platyias patulus Müller

Platyias quadricornis Ehrenberg

Trichortria sp. Bory de St. Vincent

Subfamily: Colurinae

Lepadella sp. Bory de St. Vincent

Remarks. - Lepadella sp. was totally absent from all collections from all sites until April and May. On May 23, this genus experienced a short-lived but strong increase. Qualitative data for this date revealed its composition as over 90 percent of the total at Sites 2 and 3, and over 20 percent at Sites 5 and 6. However, it composed only 3.7 percent of the 768 organisms counted at Site 4 (Tables 3 - 8). An examination of the Site 4 composition on May 23 reveals that Brachionus bidentata, B. calyciflorus, Euchlanis sp., and copepod nauplius larvae made up 83.0 percent of the total, whereas at Sites 2, 3, 5, and 6 this group comprized only 1.6, 2.2, 47.3, and 47.0 percent, respectively (Tables 4 - 8). The frequency occurrence of Lepadella sp. on May 23 increased about fourfold from Sites 5 and 6 to Sites 2 and 3; a substantial downstream increase in percentage composition.

Family: Lecanidae

Lecane luna Müller

Monostyla sp. Ehrenberg

Family: Notommatidae

Cephalodella sp. Bory de St. Vincent

Remarks. - Cephalodella sp. was not encountered until April 25. This rotifer occurred in only four of the qualitative samples but was the predominant form at Site 1 on May 9 in the quantitative collections.

Family: Trichocercidae

<u>Trichocera</u> sp. Lamarck

<u>Remarks</u>. - Qualitative collections show the absence of this form at all sites except Site 4 (Table 2). Quantitative samples show at least one occurrence at Sites 1, 5, and 6 with the latter two sites having <u>Trichocera</u> sp. as the dominant rotifer on May 16 (Figs. 21 and 22).

Family: Asplanchnidae

<u>Asplanchna</u> sp. Gosse

<u>Remarks</u>. - This was the largest rotifer occurring in Polecat Creek and it appeared more infrequently downstream from Site 4 in the qualitative collections (Table 2). The highest percentage composition occurred at Site 6 on June 13 (Table 8).

Family: Synchaetidae

<u>Synchaeta</u> sp. Ehrenberg

<u>Remarks</u>. - <u>Synchaeta</u> sp. first appeared between late February and early March at all sites. Quantitative samples show this form as the predominant zooplankter at Site 6 on June 13, whereas the qualitative data for the same site indicate its absence (Tables 3 - 11, Figs. 19 and 22). In all collections, very few individuals were found below Site 4 (Table 2).

Polyarthra dolichoptera Idelson

Order: Flosculariaceae

Family: Testudinellidae

Filinia longiseta Ehrenberg

Testudinella sp. Bory de St. Vincent

Trochosphaera sp. Semper

Undetermined taxon:

Unknown 1 (Fig. 11)

Unknown 2

Remarks. - This nonloricate rotifer could not be identified since its shape collapsed due to formalin preservation. However, its reaction to formalin was consistant and its collapsed condition could be repeatedly recognized (Fig. 11). Unknown 2 had its earliest appearance in April for all collections. Qualitative data indicate its absence from Sites 1, 2, 3, and 6 (Table 2) and low percentage occurrences at Sites 4 and 5 (Tables 6 and 7). Quantitative data show this form to be present in almost half of the collections with predominance occurring at Sites 1 and 5 on April 18 (Tables 9 - 11).

Unidentified nonloricate rotifers

Remarks. - These nonloricate rotifers could not be identified in their collapsed condition nor could they be repeatedly recognized. These forms occurred in 49 percent of the qualitative collections at Sites 1 - 6, appearing most frequently at Sites 4 - 6 (Table 2). The quantitative samples contained this form 51 percent of the time (Table 2). Both collection methods show that April was the month when these rotifers were most abundant (Tables 3 - 11).

Phylum: Arthropoda (Classification by Meglitisch, 1967)

Class: Brachiopoda

Order: Diplostraca

Suborder: Cladocera

Family: Polyphemidae

Polyphemus pediculus (Linne')

Family: Sididae

Diaphanosoma brachyurum (Liéven)

Remarks. - Diaphanosoma brachyurum had the most elaborate setation on its very large first antennae of any cladoceran found during the study. The first appearance of this form was April 11 at Site 4 (Table 6). D. brachyurum was not encountered again until May 30, afterwhich it became frequent in the collections from Sites 4 - 6, comprising one to five percent of the total (Tables 6 - 8). This form was completely absent from all other collections from Sites 1 - 3 (Table 2).

Family: Daphnidae

Daphnia longispina O. M. F.

Remarks. - This form was absent in all collected samples below Site 4, with the exception of one occurrence at Site 3 (Table 2). D. longispina occurred in 33 percent of the qualitative collections from Sites 4 - 6, with its first appearance being March 7 (Tables 3 - 8). Analysis yielded only two instances of dominance; June 6 at Sites 4 and 5, with the latter instance being also the predominant zooplankter (Figs. 17 and 18).

Daphnia pulex Leydig

Daphnia sp. O. F. Müller

Simocephalus sp. Schødler

Scapholeberis kingi Sars

Ceriodaphnia lacustris Birge

Ceriodaphnia megalops Sars

Ceriodaphnia reticulata (Jurine)

Remarks. - Qualitative data show the absence of this form at Sites 1 - 3, while quantitative samples indicate its absence at Sites 1, 5, and 6 (Table 2). C. reticulata appeared most frequently during latter May and early June, but never exceeded five percent of the total (Tables 6 - 8).

Ceriodaphnia sp. Dana

Moina affinis Birge

Moina brachiata (Birge)

Remarks. - This cladoceran was absent in qualitative collections from Sites 1 - 3, but first appeared at Sites 4 - 6 on June 6. M. brachiata was the dominant cladoceran at Site 6 on June 6, comprising 9.9 percent of the 121 total (Tables

6 - 8, Fig. 19). This species was not encountered by quantitative methods.

Moina micrura Kurz

Moina sp. Baird

Family: Bosminidae

Bosmina longirostris O. F. Müller

Family: Macrothricidae

Ilyocryptus spinifer Herrick

Macrothrix rosea (Jurine)

Family: Chydoridae

Alona affinis (Leydig)

Remarks. - This form first appeared in qualitative collections on February 21 and occurred frequently thereafter (Tables 3 - 8). *A. affinis* was the dominant cladoceran at Site 1 on April 11 and May 2, and at Site 2 on March 7 (Figs. 14 and 15).

Alona coata Sars

Alona guttata Sars

Chydorus sphaericus (O. F. Müller)

Remarks. - *Chydorus sphaericus* was the most common cladoceran in Polecat Creek, occurring in 72 percent of all collections (Table 2). Dominant cladoceran status was held by *C. sphaericus* in 80 percent of the qualitative collection while only eight percent had this form as the predominant zooplankter (Figs. 14 - 19). Qualitative collections show that this caldoceran had its highest frequency occurrence values (18 - 51 percent) in February, March, and May (Tables 3 - 8).

Quantitative collections contained C. sphaericus in 17 of the 33 collections, 15 of which it was the dominant cladoceran (Tables 9 - 11, Figs. 20 - 22). Both qualitative and quantitative samples show a downstream decrease of the number of samples in which C. sphaericus was present as well as in its frequency as the dominant cladoceran.

Kurzia latissima (Kurz)

Pleuroxus denticulatus Birge

Undetermined taxon

Unidentified Cladocera

Subclass: Copepoda

Nauplius larvae

Remarks. - Nauplius larvae were the most commonly occurring representatives of Copepoda and frequently were the most common Crustacea. These forms were found in 87 percent of all samples collected for this study (Table 2). Qualitative collections show that nauplius larvae were the dominant copepod form in 84 percent of the qualitative collection with 24 percent of the figure also having the dual status of predominant zooplankter (Figs. 14 - 19). Quantitative data show these forms dominant in 73 percent of its collections (Table 2) with 24 percent of this figure also having the second status of predominant zooplankter (Figs. 20 - 22). The instances in which these forms ranked as the predominant zooplankter occurred mostly at Sites 1 and 2. Both collection techniques show that nauplius larvae had the highest frequency values during April, May, and June.

Order: Calanoida

Family: Diaptomidae

Calanoid copepodid

Diaptomus pallidus Herrick

Remarks. - This copepod has the distinction of being the largest zooplankter collected as well as the only adult member of Calanoida. The examination of qualitative collections indicate its absence at Sites 1 and 2, one single occurrence at Site 3, and its presence in 57 percent of the collections taken at Sites 4 - 6 (Table 2). None of these collections had D. pallidus exceeding four percent of the total. Quantitative data show its presence only once at Sites 5 and 6, respectively (Table 2).

Order: Cyclopoida

Family: Cyclopoidae

Cyclopoid copepodid

Remarks. - These immature cyclopoid copepods appeared 84 of the 99 qualitative collections; 50 of these occurrences being from Sites 4 - 6 (Table 2). Sites 1 - 3 had five instances in which this form reached predominant status while Sites 4 - 6 had only one such occurrence (Figs. 14 - 19). Both quantitative and qualitative collections showed that the cyclopoid copepodids reached their highest frequency percentages during the latter part of May and early June (Tables 3 - 11).

Cyclops bicuspidatus S. A. Forbes

Cyclops sp. O. F. Müller

Ectocyclops phaleratus (Koch)

Eucyclops agilis (Koch)

Remarks. - *Eucyclops agilis* was the most common adult cyclopoid copepod in all collections. *E. agilis* appeared at all sites in low numbers and never was the dominant copepod. At the upstream sites, *E. agilis* appeared in more of the qualitative collection and had lower percent frequency values than that found at the downstream sites (Tables 3 - 8). Qualitative and quantitative data indicate a peak in frequency occurrence for this form between April and June.

Paracyclops fimbiratus (Fischer)

Mesocyclops edax (S. A. Forbes)

Orthocyclops modestus E. B. Forbes

Unknown 4 (Fig. 12)

Order: Harpacticoida

Family: Canthocamptidae

Harpacticoid copepodid

<u>Remarks</u>. - Qualitative samples show that harpacticoid copepodids occurred at least once at every site (Table 2). This rare form was the dominant copepod at Site 2 on April 11, but it should be noted that only a total of 6 organisms was encountered for that particular collection (Fig. 15).

Attheyella illinoisensis S. A. Forbes

Attheyella sp. Brady

Canthocamptus robertcokeri M. S. Wilson

Canthocamptus sp. Westwood

Order: Caligoida

Unknown 3 (Fig. 12)

Subclass: Ostracoda

<u>Remarks</u>. - This group, as a whole, was represented the least and generally had the lowest percent frequency values. Only nauplius larvae and four adult form (Unknown 5 - 8) (Fig. 13) could be recognized by the methods used for this study.

Nauplius larva

<u>Remarks</u>. - These small forms occurred in 60 of the 99 qualitative collections (Table 2). In 53 of the above 60 collections, nauplius larvae ranked as the dominant ostracod

form (Figs. 14 - 19). The number of collections which contained this form was slightly higher for the downstream sites than those located upstream (Table 2).

Unknown 5 (Fig. 13)

Remarks. - This form appeared in only five of the qualitative collections, all occurring at Sites 1 - 3. Unknown 5 was absent from all quantitative collections (Table 2).

Unknown 6 (Fig. 13)

Remarks. - Qualitative samples encountered this form for the first time in March. Unknown 6 appeared in 14 qualitative collections with three instances of dominance. Quantitative data show this form appearing in only two collections, both times as the dominant ostracod at Site 1 (Tables 3 - 11, Figs. 14 - 22).

Unknown 7 (Fig. 13)

Remarks. - This form was present in six of the qualitative samples, two instances in which is ranked as dominant. Both methods of sampling indicated its absence at Sites 1 and 6 (Tables 2 - 11).

Unknown 8 (Fig. 13)

Remarks. - Unknown 8 was the largest Ostracoda form and did not appear until April. This large ostracod appeared in only five of the qualitative and two of the quantitative collections (Tables 2 - 11).

Unidentified Ostracoda

<u>Remarks</u>. - There were only four plankton samples which contained adult Ostracoda which could not be recognized as Unknown 5 - 8 (Table 2).

<u>Combined qualitative data:</u>

Table 12 contains the percent frequency occurrence values for the major taxonomic groups from the combined qualitative samples. In most instances Rotifera comprised the largest percentage of the total, followed by Copepoda, Cladocera, and Ostracoda. Rotifera exhibited a very evenly graduated increase in percent frequency occurrence from 42.4 percent at Site 1 to 60.2 percent at Site 6. Cladocera also experienced such a gradual increase from 8.0 percent at Site 1 to 18.1 percent at Site 4, afterwhich the values reached a plateau and then decreased slightly. Both Copepoda and Ostracoda manifested a decrease in frequency values from Site 1 to Site 6. Also note that a greater number of organisms was encountered at the upstream site than at any of the downstream stations.

<u>Qualitative vs. quantitative method</u>:

Since quantitative samples were taken only at Sites 1, 5, and 6, from April 4 to June 13, a comparison can be made between this and the qualitative method of sampling by combining the data from both sampling techniques for the above inclusive dates and sampling sites. Table 13 provides the percent frequency values for the four major taxonomic groups as derived from the combined qualitative and quantitative collections taken between April 4 and June 13, at Sites 1, 5, and 6. The combined qualitative data from Site 1 showed Copepoda to have the highest percentage value followed by Rotifera, Ostracoda, and Cladocera. Quantitative samples for the same site ranked Rotifera with the highest value followed by Copepoda, Ostracoda, and Cladocera. It is clear that Site 1 had the greatest spread between percentage values as derived by the two collection methods. Both collection methods for Sites 5 and 6 possessed the same ranking order as found in Table 12.

In every instance the combined data show that the quantitative method yielded a higher percentage for Rotifera than the information derived qualitatively while for Cladocera and Ostracoda the reverse was true. With the exception of Site 1, Copepoda comprised a smaller percentage by the qualitative method. The qualitative method concentrated many times the number of organisms than that of the quantitative method at Sites 5 and 6. However, the numbers of organisms collected by either method at Site 1 were approximately equal.

Zooplankton populations:

Since the quantitative samples involved the concentration of a known volume of water, the number of organisms per volume could be calculated. The result of these calculations are found in Table 14. Site 5 had a mean concentration value of 149 organisms per 100 liters which was less than the mean values found at either Site 6 or 1. There were eight instances of a zooplankton decrease from Site 6 to Site 5, eight instances of a decrease from Site 5 to Site 1, but only five instances (April 4, May 2, 16, 30, and June 13) when there was a continuous decrease from Site 6 to Site 1. The mean values for these calculations indicate about a 14 percent decrease from Site 6 to Site 5, but also suggest an increase tendency from Site 5 to Site 1.

There was an unusually high population (924/ 100 l.) occurring at Site 1 on April 25. An examination of Table 9 reveals that 144 organisms were encountered during analysis of the above sample, which was more than twice the number encountered for any of the qualitative collections at Site 1 (Table 3) or any other quantitative samples (Tables 10 and 11). In this exceptional April 25 collection, Philodina sp. was the predominant zooplankter, comprising 30.5 percent of the quantitative total (Table 9). Also, the quantitative collections from Site 1 had Philodina sp. exhibiting dominance and predominance more often than at any other sampling site. The ranking of Philodina sp. as the predominant, quantitative zooplankter at Site 1 on April 25 was especially strange since Brachionus calyciflorus was the predominant form in all other collections along the stream for that date (Tables 3 - 11).

Comparisons of the 16 populations measurements containing over 100 organisms per 100 liters (Table 14) with turbidity levels (Fig. 8) render some correspondence. Nine of the

16 instances of high increases coincided with turbidity levels over 80 F. T. U.

Species variety:

Table 15 contains a listing of the number of different zooplankton species occurring in every collection taken during the study. Note that the higher numbers of individual, different zooplankters, on any given date, was always found at Sites 4 - 6 for the qualitative sampling with Site 4 usually having the highest number. Quantitative collections usually yielded a smaller number of different zooplankters than did the qualitative method. Data from both collection methods indicate a gradual increase of the number of zooplankton forms appearing in the weekly samples from Sites 4 - 6, while Sites 1 - 3 lack evidence for such a trend. An examination of the figures at the bottom of Table 2 reveals that Sites 4 - 6 had more species than Sites 1 - 3, with Site 4 having the greatest variety of zooplankton fauna.

The high turbidity measurements on April 25, May 9, and June 6 (Fig. 8) coincided with an increase in the variety of the zooplankton fauna at most of the sampling sites (Table 15).

Species diversity indices:

Diversity indices were computed with an information measure equation (Margalef, 1968), $D= -\sum p_1 \log_2 p_1$, using the combined, qualitative collections for February, March, April, May, and June, respectively. The results of these computations are found in Table 16. The 71 zooplankton taxa (Table 2) occurring in Polecat Creek, expressed species diversity index values ranging from 1.80 to 4.17. A brief examination of Table 16 reveals that May and June generally experienced much higher diversity values than February through April. Sites 4 - 6 had a smooth increase in diversity from February to June while values for Sites 1 - 3 were very irregular. It should be also noted that the location of the highest diversity values shifted from Sites 1 - 3 during February, March, and April to Sites 4 - 6 for May and June.

VII. DISCUSSION

The oxygen levels in Polecat Creek never dropped below seven milligrams per liter. The water quality data for portions of Polecat Creek by Chance (1968), Durham and Whitley (1971), and Brummett (1972) reported no instances of dissolved oxygen dropping below seven milligrams per liter. Dissolved oxygen appeared to follow seasonal succession.

The oxygen richness at Site 3 may have been due to the intense aeration by numerous riffle areas as the stream flows through unshaded fields. Also, the substrate at Site 3 may have contributed more dissolved oxygen by the photosynthetic action of the sometimes lush growths of *Cladophora*.

Reinhard (1931) stated that dissolved oxygen is probably not a limiting factor for most zooplankton since large swarms of Crustacea have been observed in lake water so devoid of oxygen that the fish populations have succumbed.

Table 1. Summary of the physical and chemical parameters for Sites 1 - 6 on the lower 7.6 kilometers of Polecat Creek, Coles County, Illinois. Water samples were taken on a weekly basis from Feb. 21 to Jun. 13, 1975. The standard deviation from the mean is given in each case.

Parameter	No. of samples	Mean value	Standard deviation from mean	High-low values	Range
Dissolved oxygen (mg./l. O_2)					
Site 1	17	10.7	± 1.8	13.6-7.4	6.2
Site 2	17	11.0	± 1.8	13.9-8.5	5.4
Site 3	17	11.3	± 1.9	15.5-8.2	7.3
Site 4	16	10.2	± 1.6	12.6-7.5	5.1
Site 5	17	10.2	± 1.8	12.9-7.3	5.6
Site 6	17	10.3	± 1.8	13.2-7.2	6.0
Nitrogen nitrate (mg./l. NO_3-N)					
Site 1	17	23.3	± 3.7	34.3-15.6	18.7
Site 2	17	25.1	± 5.2	37.0-17.0	20.0
Site 3	17	26.0	± 4.3	32.8-18.5	14.3
Site 4	17	25.7	± 4.5	38.5-20.2	18.3
Site 5	17	26.6	± 4.0	36.2-20.2	16.0
Site 6	17	26.7	± 3.7	35.9-20.7	15.2
Soluble (ortho-) phosphate (mg./l. P)					
Site 1	17	.45	± .27	1.15-.08	1.07
Site 2	17	.40	± .23	1.00-.11	.89
Site 3	17	.50	± .38	1.69-.14	1.55
Site 4	17	.53	± .45	1.98-.18	1.80
Site 5	17	.68	± .88	4.00-.12	3.92
Site 6	17	.54	± .46	2.04-.10	1.94

Table 1. (continued)

Parameter	No. of samples	Mean value	Standard deviation from mean	High-low values	Range
Calcium hardness (mg./l. $CaCO_3$)					
Site 1	17	178	± 42.5	250-100	150
Site 2	17	173	± 40.0	250-115	135
Site 3	17	178	± 27.6	245-110	135
Site 4	17	178	± 37.2	245-100	145
Site 5	17	176	± 30.6	240-120	120
Site 6	17	178	± 29.9	220-120	100
Total Hardness (mg./l. $CaCO_3$)					
Site 1	17	252	± 34.1	300-170	130
Site 2	17	261	± 31.3	300-200	100
Site 3	17	256	± 27.4	300-200	100
Site 4	17	253	± 29.9	295-200	95
Site 5	17	259	± 29.8	300-200	100
Site 6	17	251	± 35.1	290-140	150
Hydrogen ion concentration (pH)					
Site 1	17	7.8	± .6	9.0-6.9	2.1
Site 2	17	7.9	± .5	9.0-7.1	1.9
Site 3	17	7.9	± .4	8.9-7.2	1.7
Site 4	17	7.9	± .4	8.8-7.3	1.5
Site 5	17	7.9	± .3	8.7-7.4	1.3
Site 6	17	8.0	± .3	8.7-7.4	1.3

Table 1. (continued)

Parameter	No. of samples	Mean value	Standard deviation from mean	High-low values	Range
Stream velocity (meters/ sec.)					
Site 1	17	.46	± .20	.84-0±	.84
Site 2	17	.90	± .32	1.80-.44	1.36
Site 3	17	.74	± .23	1.12-.32	.80
Site 5	17	.51	± .15	.84-.30	.54
Site 6	17	.46	± .11	.70-.30	.40
Turbidity (F.T.U.)					
Site 1	17	166	± 310.7	1250-8	1242
Site 2	17	106	± 153.5	500-8	492
Site 3	17	109	± 133.0	450-10	440
Site 4	17	193	± 404.8	1750-20	1730
Site 5	17	102	± 100.3	350-18	332
Site 6	17	134	± 247.5	1100-22	1078
Air temp. (C.°)					
Site 1	17	11.9	± 7.4	23.0-0.0	23.0
Site 2	17	13.8	± 8.2	25.0-1.0	24.0
Site 3	17	16.0	± 8.5	30.0-1.0	29.0
Site 4	16	16.6	± 9.0	31.0-2.0	28.0
Site 5	17	16.8	± 8.5	30.0-2.0	28.0
Site 6	17	15.4	± 8.5	29.0-2.0	27.0
Water temp. (C.°)					
Site 1	17	10.8	± 6.2	22.0-2.0	20.0
Site 2	17	11.7	± 6.2	23.0-3.0	20.0
Site 3	17	13.0	± 6.3	26.0-4.0	22.0
Site 4	16	12.9	± 6.6	26.0-4.5	21.5
Site 5	17	12.5	± 6.0	24.0-3.5	20.5
Site 6	17	13.4	± 6.3	25.0-5.0	20.0

Fig. 2. Dissolved oxygen levels for Sites 1 - 6 on the lower 7.6 kilometers of Polecat Creek, Coles County, Illinois, from Feb. 21, to Jun. 13, 1975.

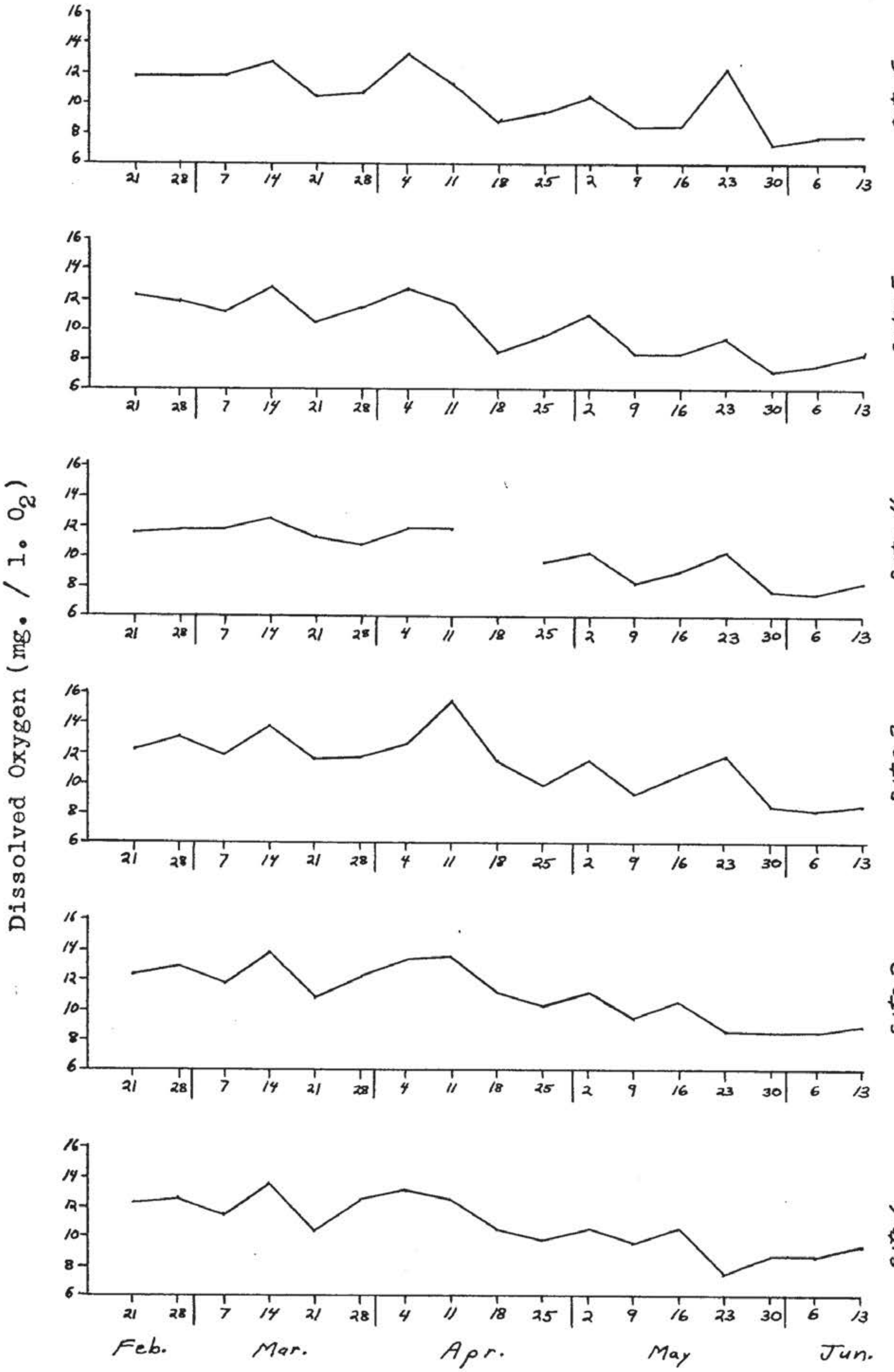

Dissolved Oxygen (mg. / l. O2)
site 6
site 5
site 4
site 3
site 2
site 1
21 28 7 14 21 28 4 11 18 25 2 9 16 23 30 6 13
Feb.
Mar.
Apr.
May
Jun.

Fig. 3. Nitrogen nitrate levels for Sites 1 - 6 on the lower 7.6 kilometers of Polecat Creek, Coles County, Illinois, from Feb. 21, to Jun. 13, 1975.

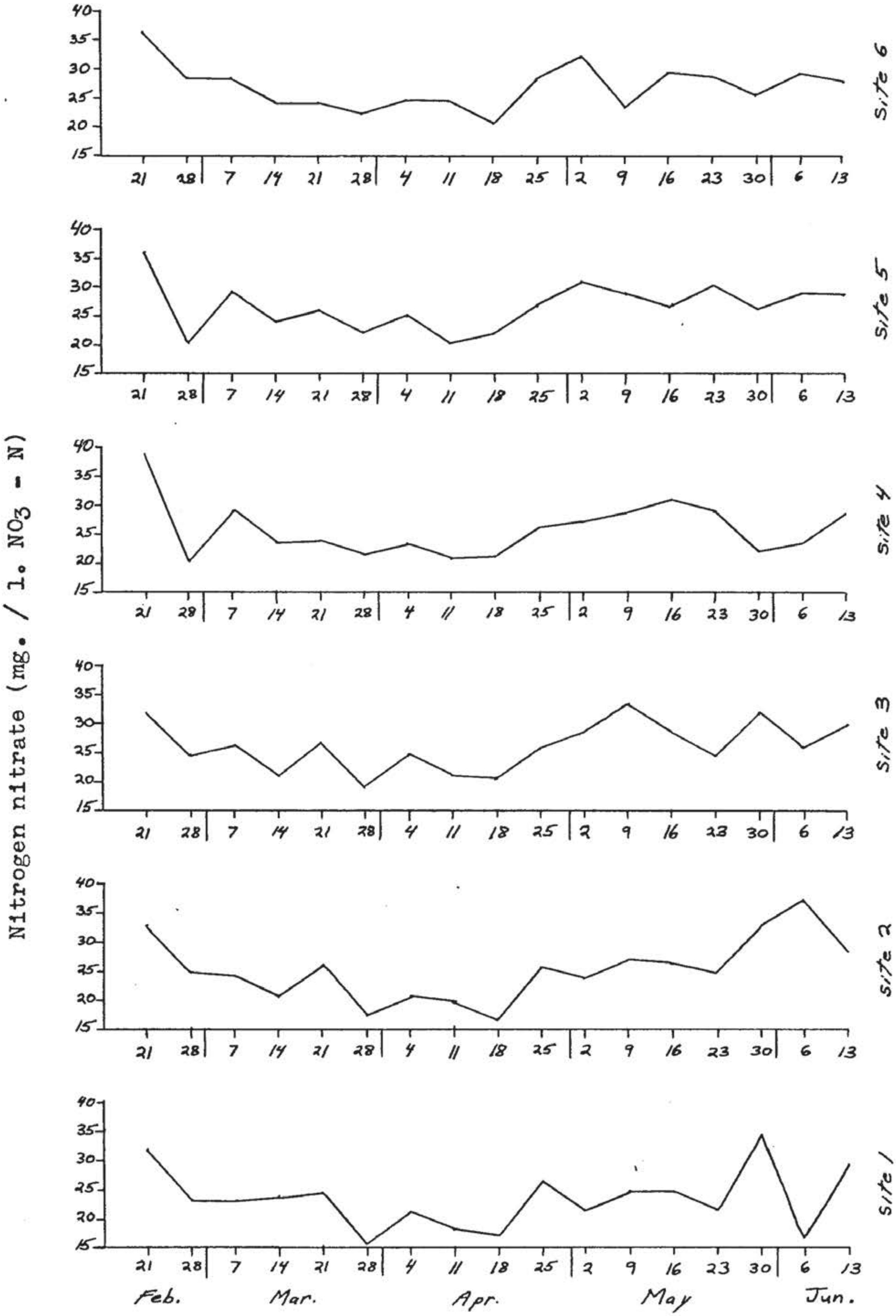

Nitrogen nitrate (mg. / l. NO3 - N)
Site 6
Site 5
Site 4
Site 3
Site 2
Site 1
40
35
30
25
20
15
21 28 7 14 21 28 4 11 18 25 2 9 16 23 30 6 13
Feb.
Mar.
Apr.
May
Jun.

Fig. 4. Soluble (ortho-) phosphate levels for sites 1 - 6 on the lower 7.6 kilometers of Polecat Creek, Coles County, Illinois, from Feb. 21, to Jun. 13, 1975.

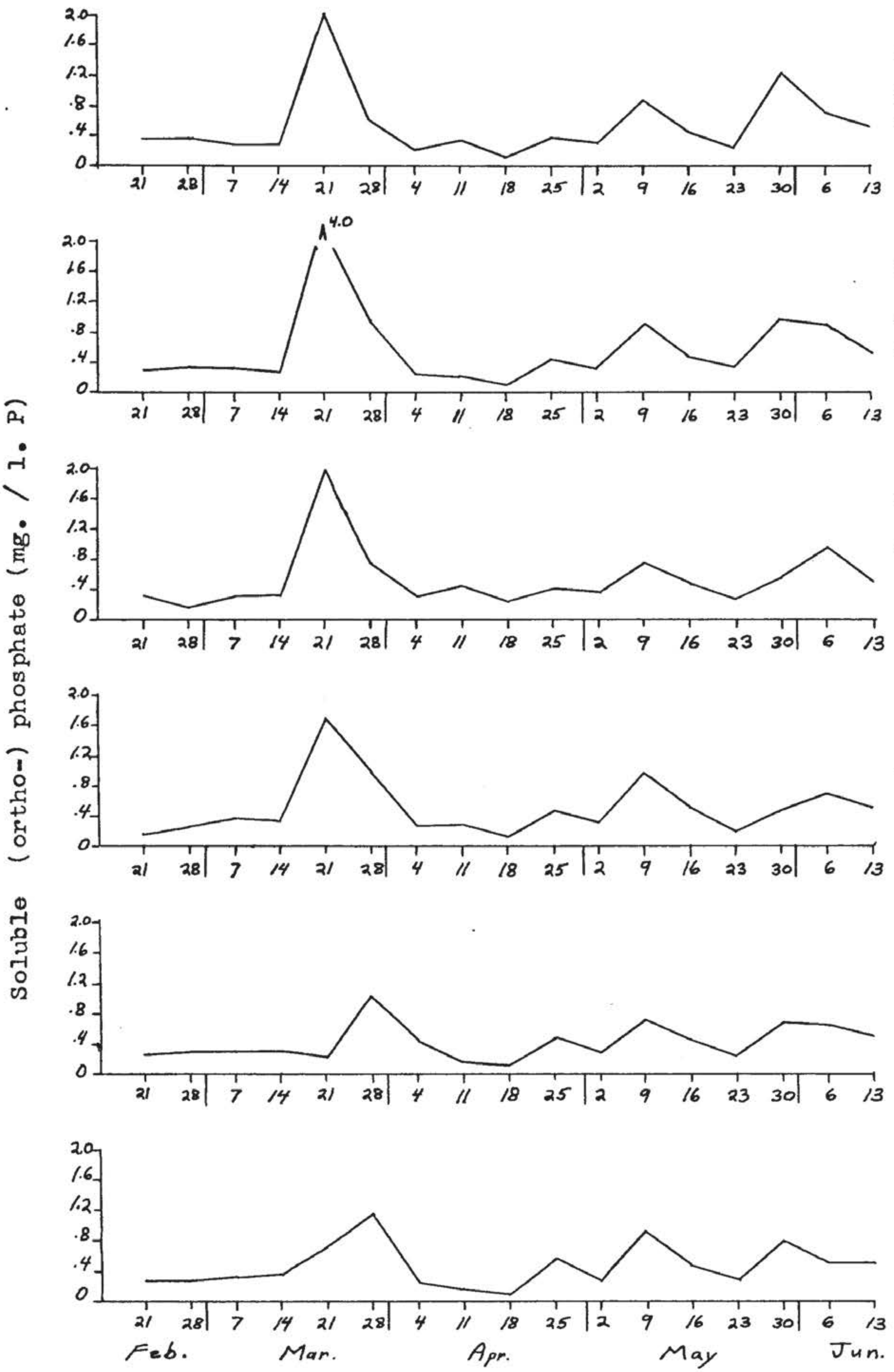

Soluble (ortho-) phosphate (mg. / l. P)
site 6
site 5
4.0
site 4
site 3
site 2
site 1
2.0
1.6
1.2
.8
.4
0
21 28 7 14 21 28 4 11 18 25 2 9 16 23 30 6 13
Feb.
Mar.
Apr.
May
Jun.

Fig. 5. Total and calcium hardness levels for Sites 1 - 6 on the lower 7.6 kilometers of Polecat Creek, Coles County, Illinois, from Feb. 21, to Jun. 13, 1975.

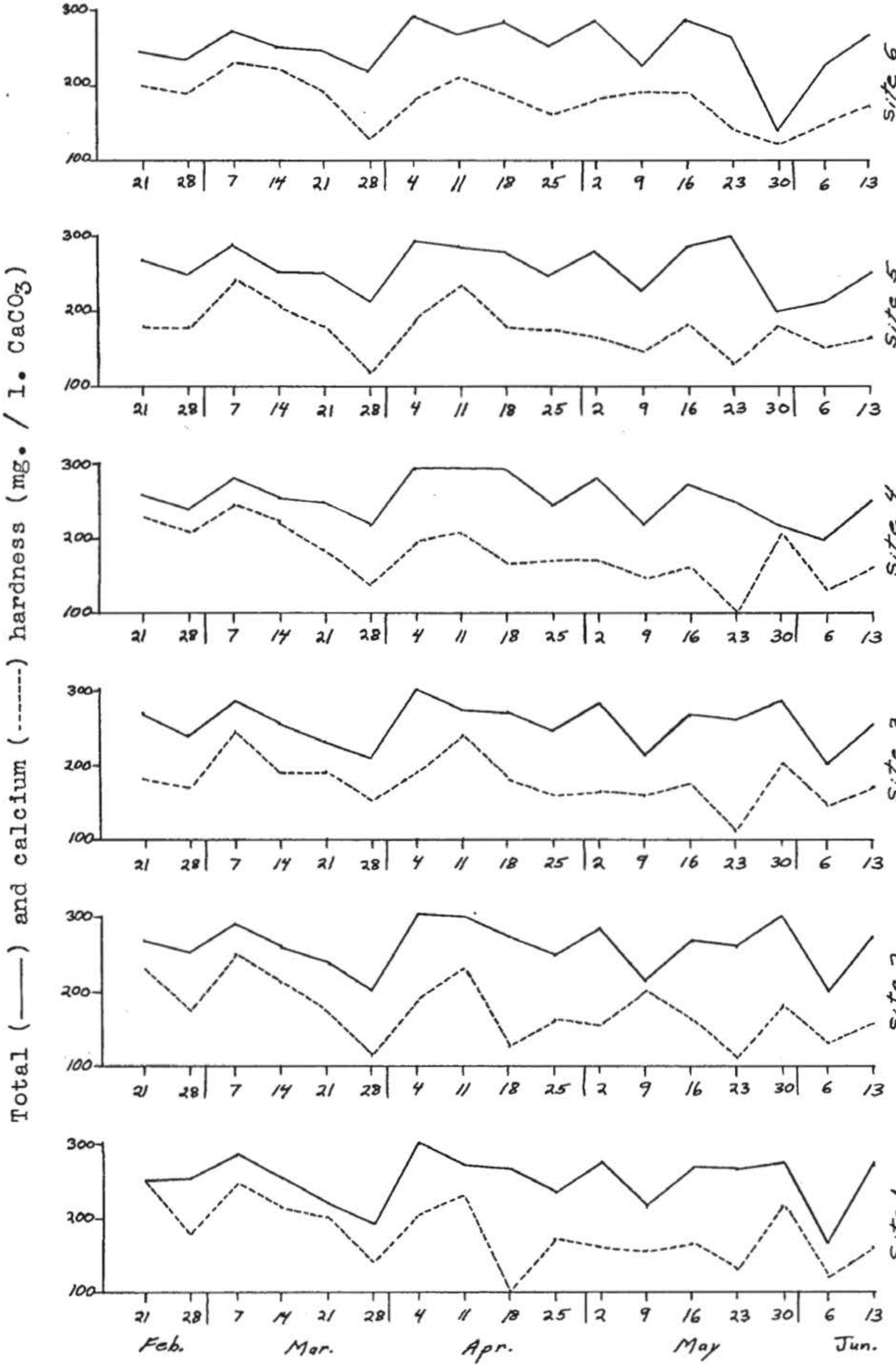
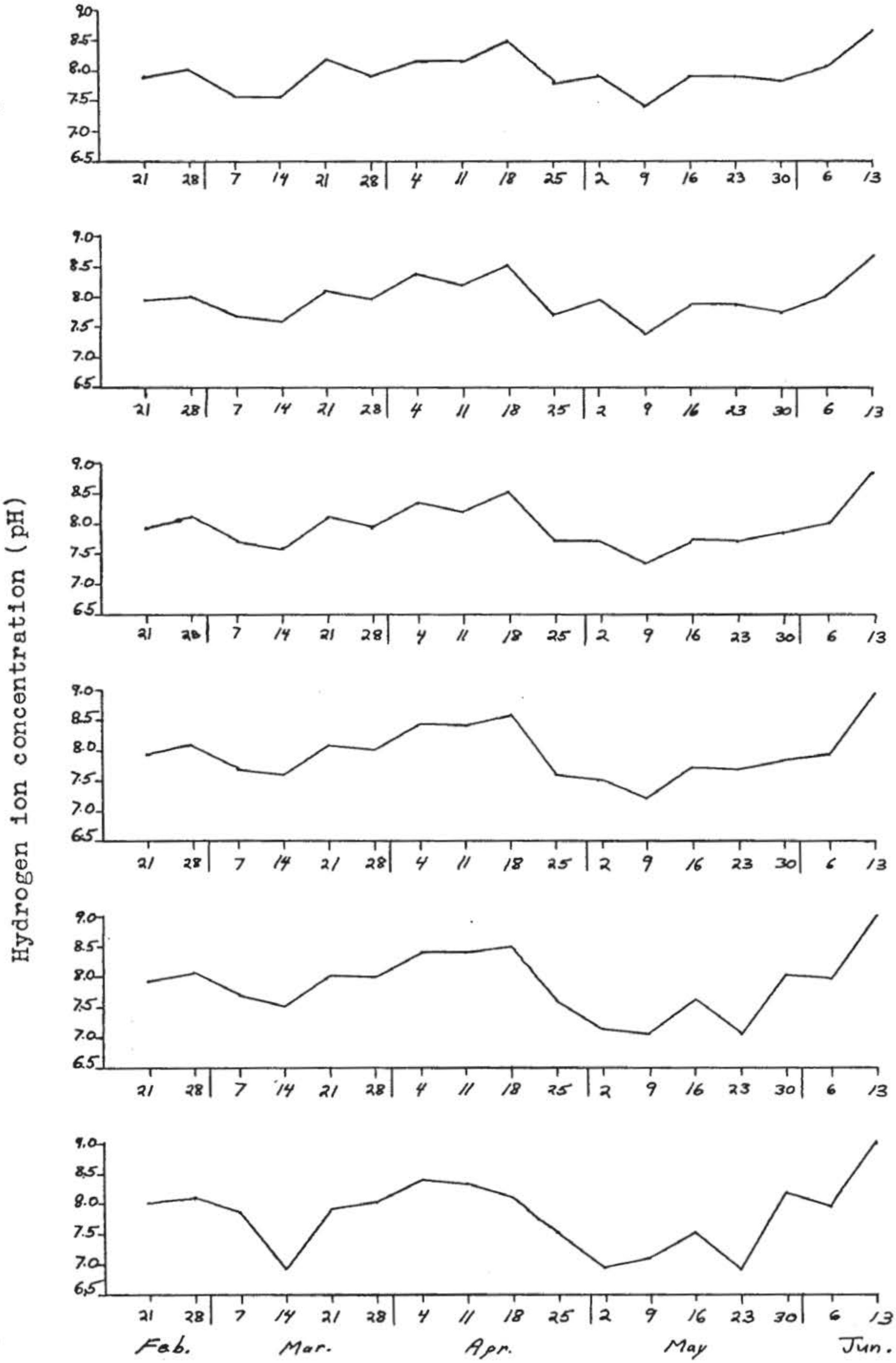

Total (——) and calcium (------) hardness (mg. / l. $CaCO_3$)
Site 6
Site 5
Site 4
Site 3
Site 2
Site 1
300
200
100
21 28 7 14 21 28 4 11 18 25 2 9 16 23 30 6 13
Feb.
Mar.
Apr.
May
Jun.

Fig. 6. Hydrogen ion concentration levels for Sites 1 - 6 on the lower 7.6 kilometers of Polecat Creek, Coles County, Illinois, from Feb. 21, to Jun. 13, 1975.


Hydrogen ion concentration (pH)
Site 6
Site 5
Site 4
Site 3
Site 2
Site 1
9.0
8.5
8.0
7.5
7.0
6.5
21 28 7 14 21 28 4 11 18 25 2 9 16 23 30 6 13
Feb. Mar. Apr. May Jun.

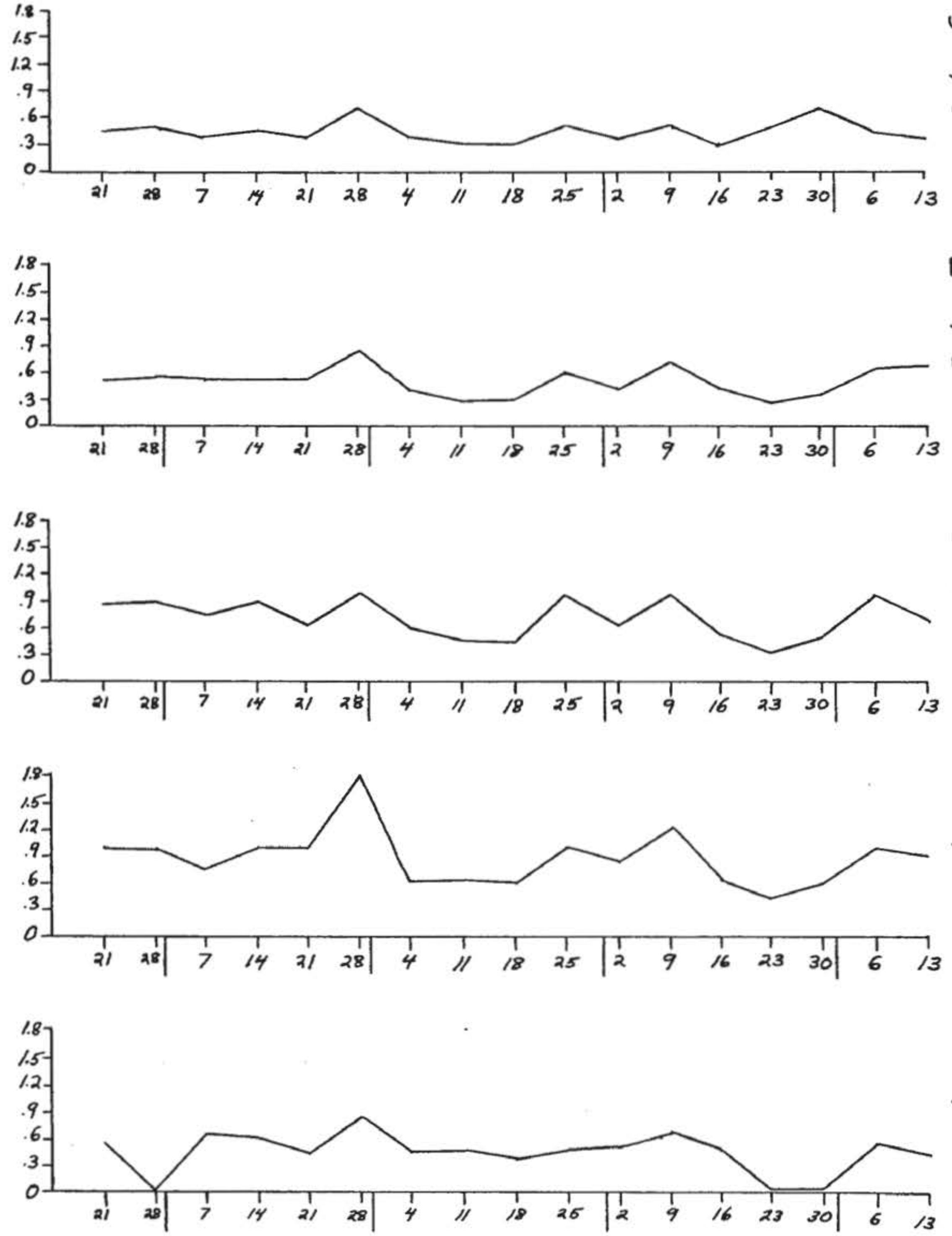


Fig. 7. Stream velocity levels for Sites 1 - 6 on the lower 7.6 kilomoters of Polecat Creek, Coles County, Illinois, from Feb. 21, to Jun. 13, 1975.

Fig. 8. Turbidity levels for Sites 1 - 6 on the lower 7.6 kilometers of Polecat Creek, Coles County, Illinois, from Feb. 21, to Jun. 13, 1975.

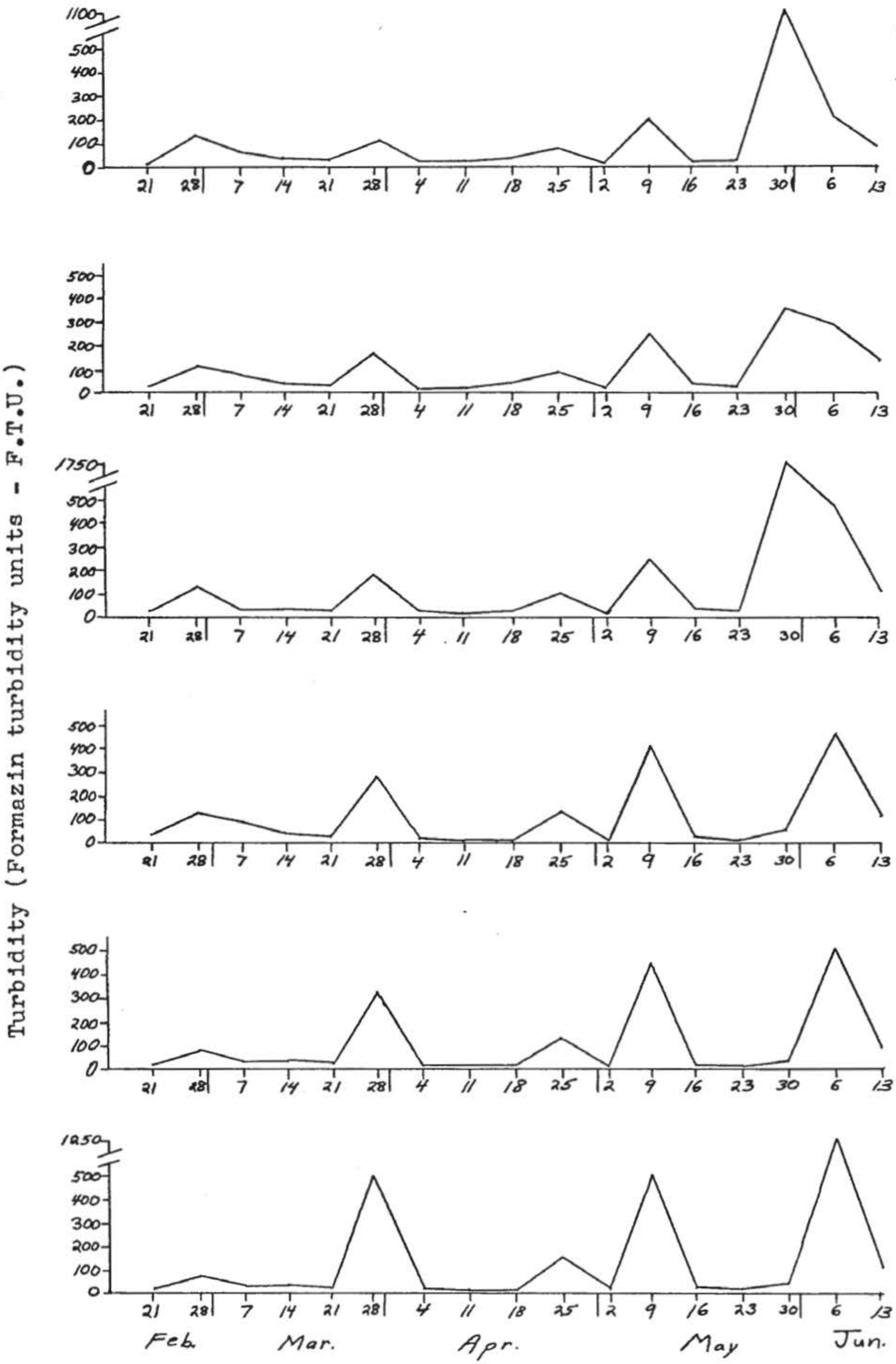
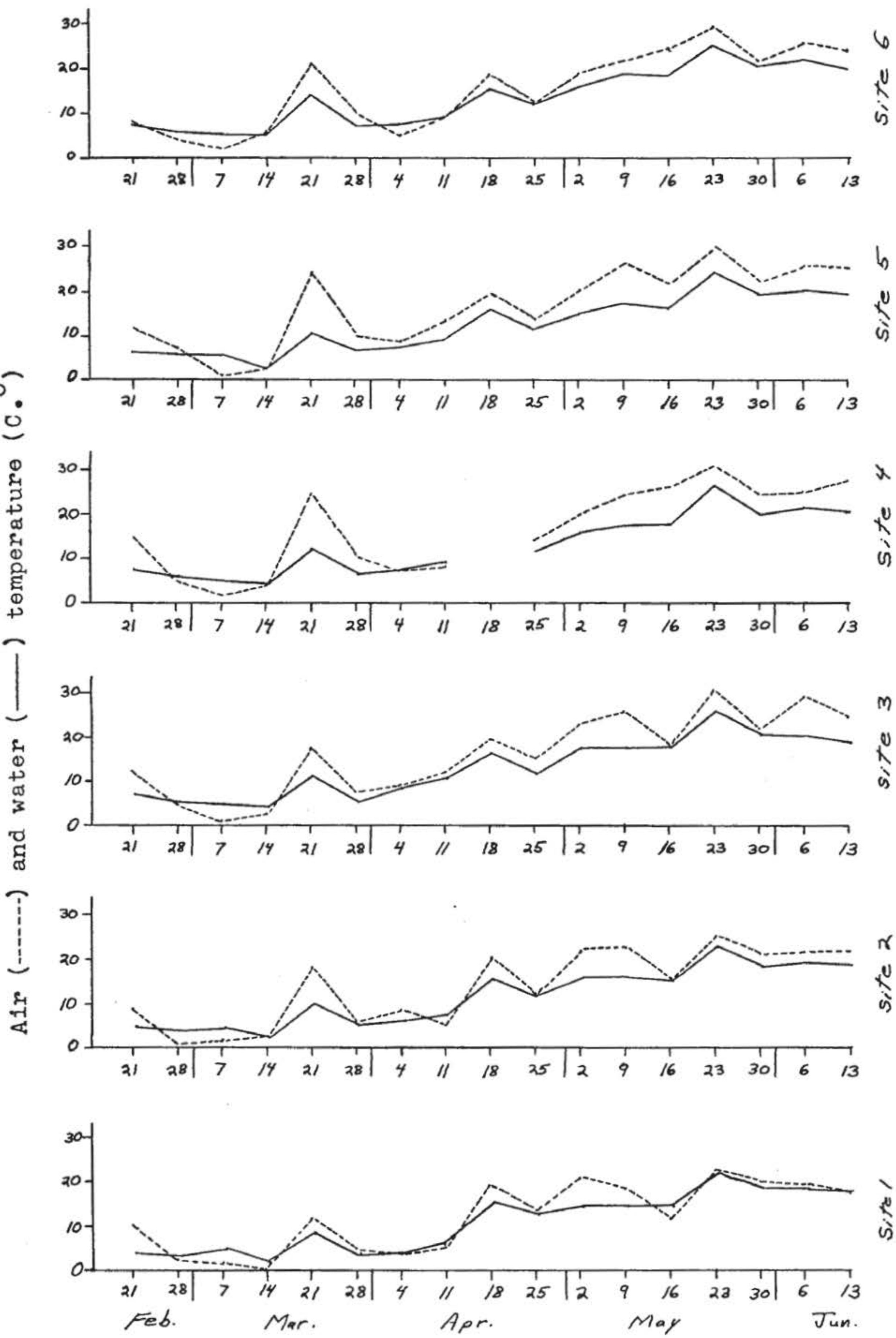

Turbidity (Formazin turbidity units - F.T.U.)
Site 6
Site 5
Site 4
Site 3
Site 2
Site 1
1100
1750
1050
0
100
200
300
400
500
21
28
7
14
21
28
4
11
18
25
2
9
16
23
30
6
13
Feb.
Mar.
Apr.
May
Jun.

Fig. 9. Air and water temperature levels for Sites 1 - 6 on the lower 7.6 kilometers of Polecat Creek, Coles County, Illinois, from Feb. 21, to Jun. 13, 1975.


Air (------) and water (——) temperature (C.°)
Site 6
Site 5
Site 4
Site 3
Site 2
Site 1
30
20
10
0
21 28 7 14 21 28 4 11 18 25 2 9 16 23 30 6 13
Feb.
Mar.
Apr.
May
Jun.

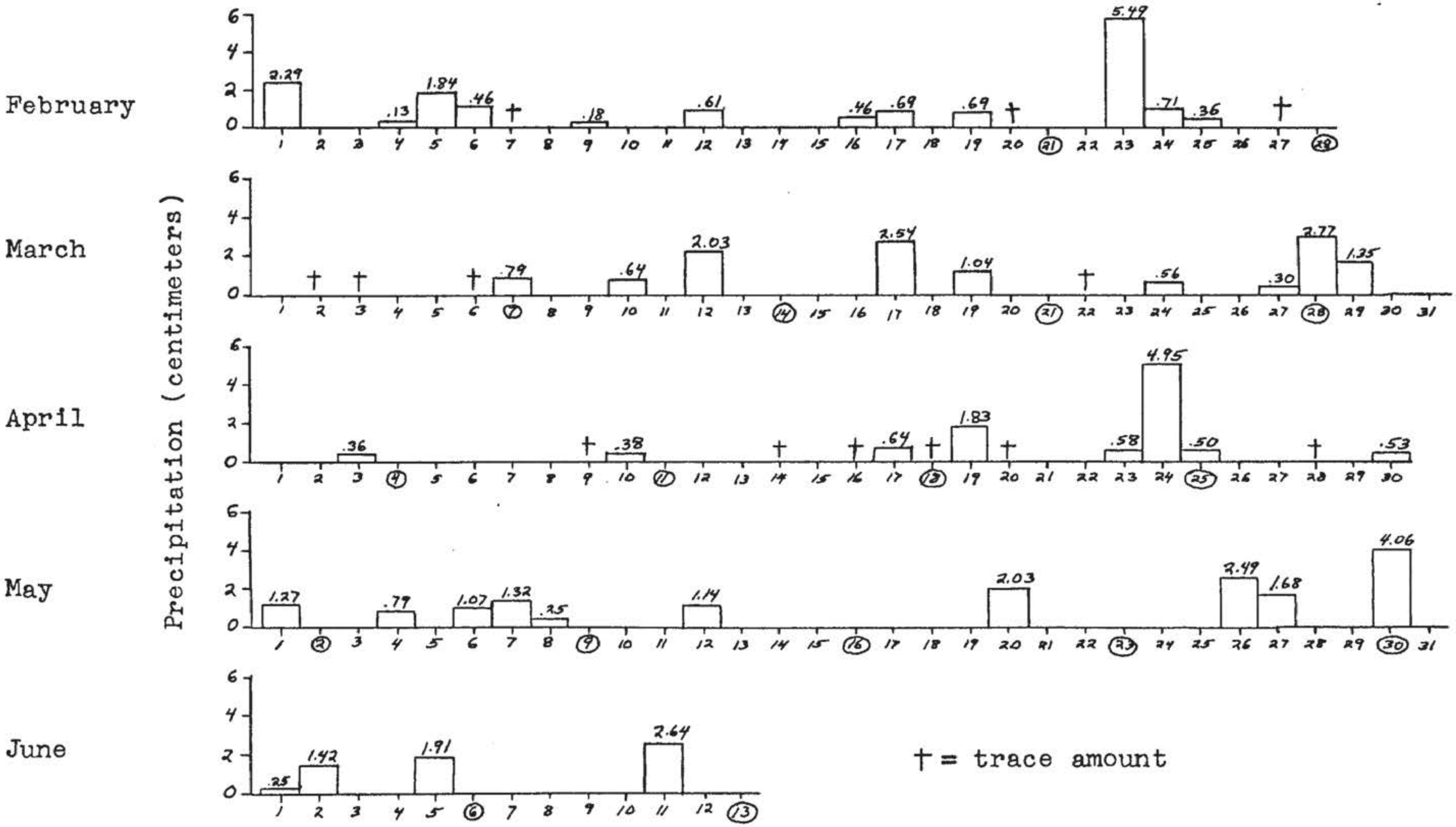


Fig. 10. Weather Bureau precipitation data for Coles County, Illinois, February 1, to June 13, 1975. The U.S. Weather Bureau station is located in the south part of Charleston, Illinois, or about eight kilometers E.S.E. from the mouth of Polecat Creek. Dates of weekly plankton collections are circled.

Table 2. Summary of all the weekly, qualitative and quantitative plankton collections taken at Sites 1 - 6 on the lower 7.6 kilometers of Polecat Creek, Coles County, Illinois, during 1975. The number of weekly collections which contain a specific zooplankton organism is indicated for each respective sampling site. Qualitative collections were taken at Sites 1 - 6 from February 21 to June 13. Quantitative collections were taken at Sites 1, 5, and 6 from April 4 to June 13.

Collection method:	Qualitative						Quantitative		
Site no.:	1	2	3	4	5	6	1	5	6
No. of weekly collections:	14	17	17	17	17	17	11	11	11
ROTIFERA:									
Asplanchna sp.	1	3	1	9	7	3			3
Brachionus angularis				4	2	4	1		1
Brachionus bidentata			2	5	5	4	2	3	4
Brachionus budapestenesis				1					
Brachionus calyciflorus	7	11	12	17	17	16	3	9	9
Brachionus caudatus				2	3	2		2	2
Brachionus havanaensis	1	1							
Brachionus quadridentatus			1	5	5	5		3	2
Brachionus rubens	1	1	2	3	5	3		1	1
Brachionus urceolaris	7	8	9	17	12	13	1	1	4
Cephalodella sp.			1	1	1	1	3		2
Euchlanis sp.	3	3	3	10	6	8			
Filinia longiseta		2	3	7	6	4	3	2	4
Keratella cochlearis	4	4	2	6	6	3	4	2	3
Keratella quadrata	1	2	2						
Keratella valga	2	3	2				2		
Lecane luna	1	1		1	1	2			3
Lepadella sp.	1	2	3	4	4	4	2	2	2
Macrochaetus sp.				1					
Monostyla sp.			1	1	1	1			
Mytilina sp.			1		2	1			
Notholca striata	2	2	2	3	1	1	3	1	
Philodina sp.	7	5	3	14	14	7	8	6	5
Platyias patulus				2			1		
Platyias quadricornis				2	1				
Polyarthra dolichoptera	1	2	1	3	2	3	1	3	5
Rotaria neptunia	2		2	4	2	4	1	2	1
Rotaria sp.			1		1				
Synchaeta sp.	2	3	4	14	11	10	4	2	4
Testudinella sp.	5	4	3	12	9	3		1	2
Trichocera sp.				1			1	1	3
Trichotria sp.			2	2					
Trochosphaera sp.				1					
Unknown 1		1				1	2	2	2
Unknown 2				2	1		5	5	6
Unident. nonloricate	7	4	6	10	14	9	6	5	6
CLADOCERA:									
Alona affinis	3	5	2	11	10	9		3	1
Alona costa				6	6	3		2	
Alona guttata		1	1		1	1			
Bosmina longirostris	2		3	6	7	6			2
Ceriodaphnia lacustris			1	1	1				
Ceriodaphnia megalops				2					
Ceriodaphnia reticulata				2	3	2			
Ceriodaphnia sp.				1		2			
Chydorus sphaericus	8	13	16	17	17	16	3	8	6
Daphnia longispina			1	7	5	5		2	2
Daphnia pulex				2		3		1	1

Table 2. (continued)

Collection method:	Qualitative						Quantitative		
Site no.:	1	2	3	4	5	6	1	5	6
No. of weekly collections:	14	17	17	17	17	17	11	11	11
CLADOCERA:									
Daphnia sp.	1		1	1	1			1	
Diaphanosoma brachyurum				3	3	2			1
Ilyocryptus spinifer				3	5	2			
Kurzia latissima					1				
Macrothrix roseus	1	1		1	1				
Moina affinis				1	1				
Moina brachiata				2	2	2			
Moina micrura				2	1	3			
Moina sp.				1					
Pleuroxus denticulatus				9	1	2			
Polyphemus pediculus					1				
Schapholeberis kingi			1	3	1	1		1	2
Unident. Cladocera			1	1	1	1			
COPEPODA:									
Nauplius larva	14	15	16	17	17	17	9	10	11
Cyclopoida:									
Copepodid	9	14	12	17	17	16	4	4	4
Cyclops bicuspidatus		1	1			1			
Cyclops sp.				4	2				1
Ectocyclops phaleratus				2					
Eucyclops agilis	7	6	6	12	14	8	2	2	2
Paracyclops fimbriatus		2	2	2	4	1			
Mesocyclops edax				1	1	2		1	
Orthocyclops modestus				1					
Unknown 4					1				
Calanoida:									
Copepodid				6	4	5			
Diaptomus pallidus			1	12	8	9		1	1
Harpacticoida:									
Copepodid	1	5	2	1	2	2	1		
Attheyella illinoisensis	1			5		2		1	
Attheyella sp.		1							
Canthocamptus robertcokeri			1	4		1	1		
Canthocamptus sp.				1					
Caligoida:									
Unknown 3				1					
OSTRACODA:									
Nauplius larva	6	13	13	11	8	8	3	1	
Unknown 5	1	2	2						
Unknown 6	2	3	1	5	3		2		
Unknown 7		1	1	2	2			1	
Unknown 8	1	1	1	2			1	1	
Unident. Ostracoda	2	1	1						
Distribution of different zooplankters for entire study:	33	36	47	71	60	52	28	35	34

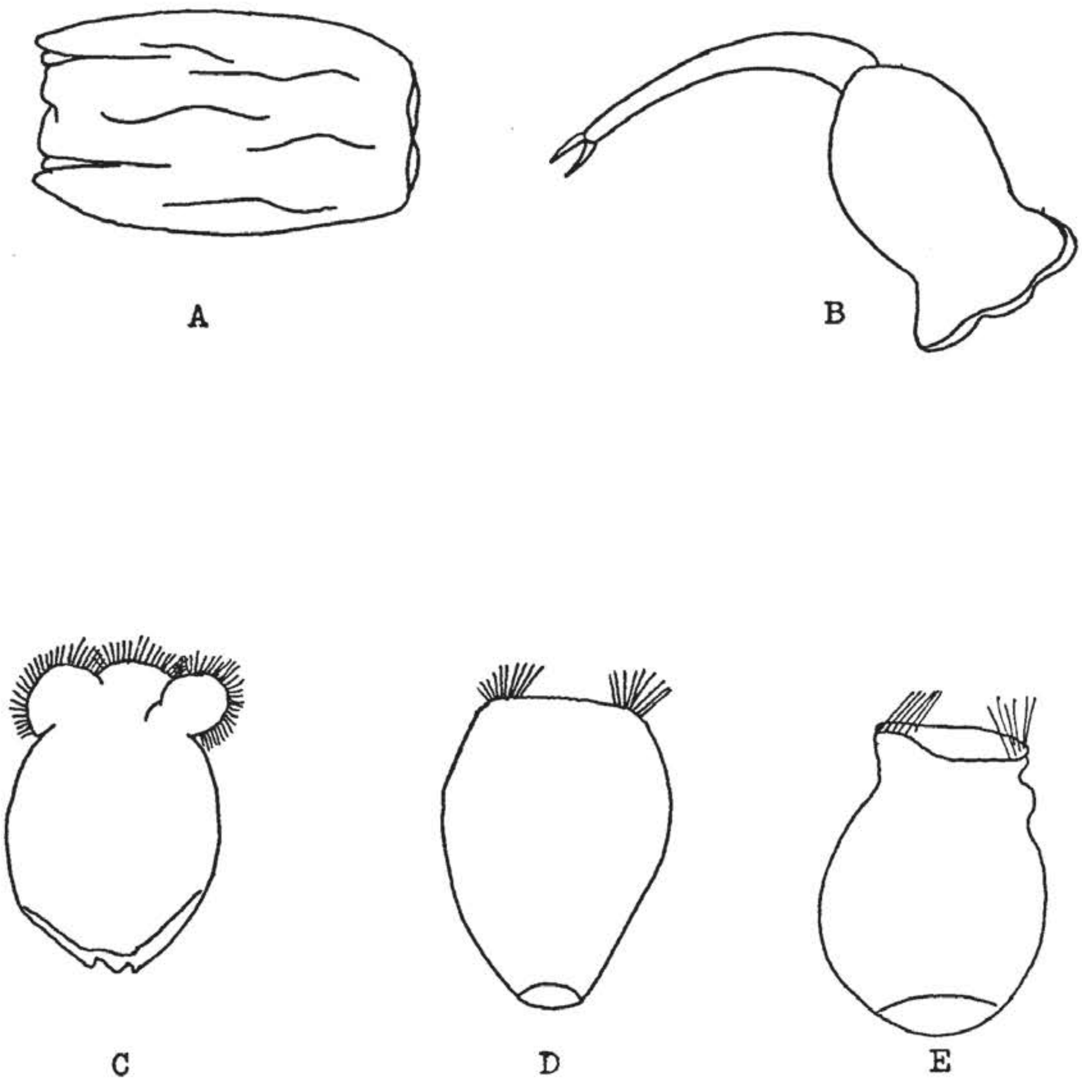


Fig. 11. Illustrations of unidentified Rotifera from Polecat Creek, Coles County, Illinois, spring, 1975. These nonloricate rotifers are shown in their contracted state due to formalin preservation. A, (Unknown 1), mean length, 146 microns; mean width, 96 microns. B, C, D, and E, (Unknown 2), mean length, 142 microns: mean width, 88 microns.

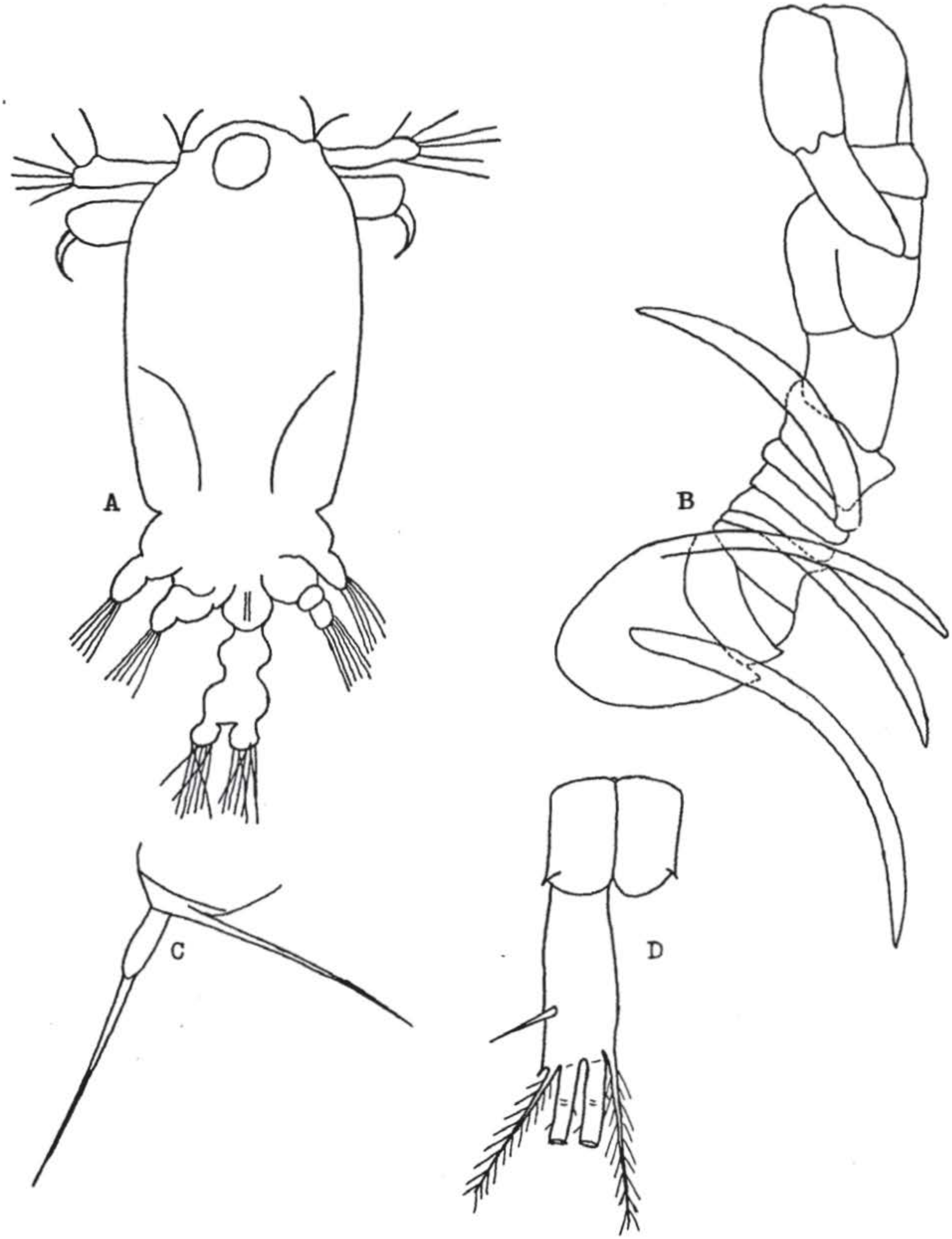


Fig. 12. Illustrations of unidentified Copepoda from Polecat Creek, Coles County, Illinois, spring, 1975. A, (Unknown 3), length, 525 microns. B - D (Unknown 4); B, first antennae of male, C, fifth leg of male, D, caudal ramus of male.

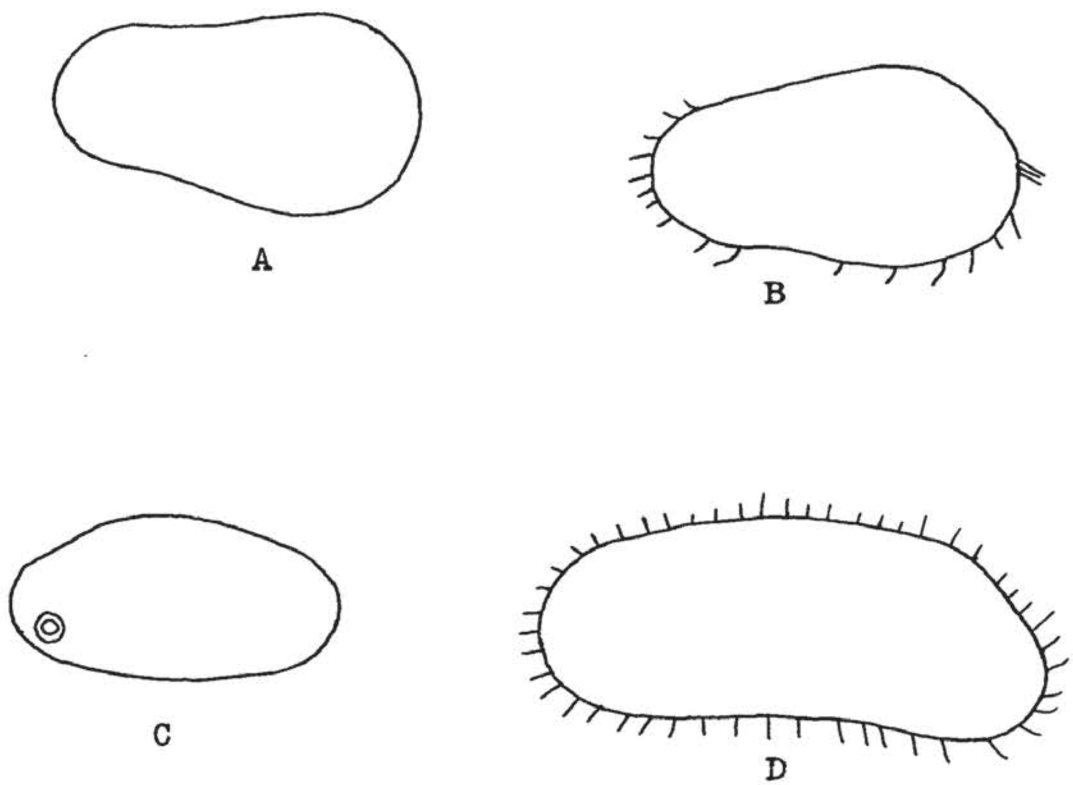


Fig. 13. Illustrations of unidentified Ostracoda from Polecat Creek, Coles County, Illinois, spring, 1975. A, (Unknown 5), length, 325 microns; B, (Unknown 6), length, 300 microns; C, (Unknown 7), length, 283 microns; D, (Unknown 8), length, 575 microns.

Table 3. Percent frequency occurrence for the total zooplankton, qualitatively collected, at Site 1, on Polecat Creek, Coles County, Illinois, from 14 weekly samples[1], 21 Feb. to 13 Jun., 1975.

Dates of Collection:	Feb. 21	Feb. 28	Mar. 7	Mar. 14	Mar. 21	Mar. 28	Apr. 4	Apr. 11	Apr. 18	Apr. 25	May 2	May 9	May 16	May 23	May 30	Jun. 6	Jun. 13
Number of Organisms:	34		1	24	11	18	12	7	12	53	26	43	31			21	6
ROTIFERA:																	
Asplanchna sp.							8.3										
Brachionus angularis																4.8	
Brachionus calyciflorus	5.9			12.5	9.1					43.4	15.4	18.6					
Brachionus havanaensis																9.4	
Brachionus rubens																4.8	
Brachionus urceolaris	29.4		100.0	54.2		5.6			8.3	9.4							
Euchlanis sp.											7.7	2.3	3.2				
Keratella cochlearis	2.9					16.6			8.3								
Keratella quadrata										5.6							
Keratella valga										3.8	3.9						
Lecane luna													3.2				
Lepadella sp.										1.9							
Notholca striata					9.1		8.3										
Philodina sp.							8.3	14.3	8.3	1.9	7.7	4.7				9.4	
Polyarthra dolichoptera																4.8	
Rotaria neptunia								14.3	8.3								
Synchaeta sp.				4.2					8.3								
Testudinella sp.					9.1		8.3			1.9		2.3	3.2				
Unident. nonloricate					9.1		16.7		16.7		3.9		6.5			4.8	
CLADOCERA:																	
Alona affinis								14.3			7.7	2.3					
Bosmina longirostris										1.9		2.3					
Chydorus sphaericus	8.8				18.2	16.6				13.2	3.9	16.3				4.8	
Daphnia sp.	2.9																
COPEPODA:																	
Nauplius larva	44.2			20.7	36.3	39.0	41.8	28.5	16.7	13.2	30.7	28.0	54.9			42.8	16.7
Cyclopoida:																	
Copepodid					9.1		8.3	14.3			11.4	16.3	12.9			4.8	49.9
Eucyclops agilis	5.9								16.8	1.9		2.3	3.2			4.8	

Table 3. (continued)

	Feb.		Mar.				Apr.				May					Jun.	
Dates of Collection:	21	28	7	14	21	28	4	11	18	25	2	9	16	23	30	6	13
Number of Organisms:	34		1	24	11	18	12	7	12	53	26	43	31			21	6
COPEPODA:																	
Harpacticoida:																	
Copepodid											7.7						
Atthellya illinoisensis				4.2													
OSTRACODA:																	
Nauplius larva						16.6		14.3				2.3	12.9			4.8	16.7
Unknown 5										1.9							
Unknown 6						5.6											16.7
Unknown 8									8.3								
Unident. Ostracoda				4.2								2.3					

[1]No qualitative collections were taken on Feb. 28, May 23, and 30, due to flooding at this site.

Table 4. Percent frequency occurrence for the total zooplankton, qualitatively collected, at Site 2, on Polecat Creek, Coles County, Illinois, from 17 weekly samples, 21 Feb. to 13 Jun., 1975.

Dates of Collection:	Feb. 21	28	Mar. 7	14	21	28	Apr. 4	11	18	25	May 2	9	16	23	30	6	13
Number of Organisms:	57	80	21	50	21	25	17	6	10	104	33	43	12	62	12	12	14
ROTIFERA:																	
Asplanchna sp.					4.8					1.0		2.3					
Brachionus calyciflorus	5.2	1.2		14.0	14.2	4.0	17.6	50.0	20.0	61.5	24.4	16.3					
Brachionus havanaensis																16.7	
Brachionus rubens										1.0							
Brachionus urceolaris	47.4	68.9	33.3	36.0		4.0	5.9			7.7		2.3					
Euchlanis sp.											6.1	7.1	8.3				
Filinia longiseta	1.8									1.8							
Keratella cochlearis		1.2							50.0	1.0	9.1						
Keratella quadrata										1.0	3.0						
Keratella valga										2.8	9.1						7.1
Lecane luna															16.8		
Lepadella sp.													8.3	92.0			
Notholca striata						4.0	5.9										
Philodina sp.						4.0			10.0		3.0	2.3					
Polyarthra dolichoptera							5.9			1.0							
Synchaeta sp.				2.0	4.8	4.0											
Testudinella sp.	3.4				4.8					1.0		2.3					
Unknown 1											3.0						
Unident. nonloricate		5.0		4.0							3.0		8.3		8.3		
CLADOCERA:																	
Alona affinis	1.8		9.5	2.0						1.0	3.0						
Alona guttata					4.8												
Chydorus sphaericus	10.5	6.3	4.8	8.0	14.2	16.0	5.9			4.8	6.1	41.9	16.8	1.6	25.0		
Macrothrix roseus		1.2															
COPEPODA:																	
Nauplius larva	21.1	6.3	47.6	22.0	42.8	24.0	35.3			9.6	12.1	4.6	33.4	1.6	8.3	33.3	21.4
Cyclopoida:																	
Copepodid	1.8	1.2		2.0	4.8	12.0	5.9		10.0	2.8	9.1	7.1		4.8	25.0	25.0	42.9
Cyclops bicuspidatus																	14.3

Table 4. (continued)

Dates of Collection:	Feb. 21	Feb. 28	Mar. 7	Mar. 14	Mar. 21	Mar. 28	Apr. 4	Apr. 11	Apr. 18	Apr. 25	May 2	May 9	May 16	May 23	May 30	Jun. 6	Jun. 13
Number of Organisms:	57	80	21	50	21	25	17	6	10	104	33	43	12	62	12	12	14
COPEPODA:																	
Cyclopoida:																	
<u>Eucyclops agilis</u>	1.8	1.2		2.0								2.3	8.3		8.3		
<u>Paracyclops fimbiratus</u>												2.3			8.3		
Harpacticoida:																	
Copepodid						4.0		16.6		1.0		4.6	8.3				
<u>Attheylla</u> sp.											3.0						
OSTRACODA:																	
Nauplius larva	5.2	7.5	4.8			20.0	17.6	33.3	10.0	1.0	3.0	2.3	8.3			16.7	14.3
Unknown 5				4.0	4.8												
Unknown 6				2.0							3.0	2.3					
Unknown 7						4.0											
Unknown 8																8.3	
Unident. Ostracoda				2.0													

Table 5. (continued)

Dates of Collection:	Feb. 21	Feb. 28	Mar. 7	Mar. 14	Mar. 21	Mar. 28	Apr. 4	Apr. 11	Apr. 18	Apr. 25	May 2	May 9	May 16	May 23	May 30	Jun. 6	Jun. 13
Number of Organisms:	105	139	62	83	40	35	26	7	13	158	39	34	6	140	16	24	13
CLADOCERA:																	
Daphnia sp.	.9																
Scapholeberis kingi																4.2	
Unident. Cladocera						5.7											
COPEPODA:																	
Nauplius larva	19.1	11.5	29.0	24.1	25.0	25.6	11.5	42.8	23.1	13.9	15.4	8.8	16.7		12.5	12.5	7.7
Cyclopoida:																	
Copepodid	2.1	2.2		1.2		5.7	7.7		15.4	2.5	5.1			.7	6.3	20.7	30.7
Cyclops bicuspidatus																4.2	
Eucyclops agilis	3.0	.7				2.9						2.9			12.5		15.4
Paracyclops fimbiratus															6.3		7.7
Calanoida:																	
Diaptomus pallidus												2.9					
Harpacticoida:																	
Copepodid	.9	.7															
Canthocamptus robertcokeri	.9																
OSTRACODA:																	
Nauplius larva	.9	1.4	6.5	1.2	32.5	5.7	19.2			1.9	2.6		16.7	.7	12.5	8.3	
Unknown 5										.6							7.7
Unknown 6					2.5												
Unknown 7											2.6						
Unknown 8																4.2	
Unident. Ostracoda	.9																

Table 6. Percent frequency occurrence for the total zooplankton, qualitatively collected, at Site 4, on Polecat Creek, Coles County, Illinois, from 17 weekly samples, 21 Feb. to 13 Jun., 1975.

	Feb.		Mar.				Apr.				May					Jun.	
Dates of Collection:	21	28	7	14	21	28	4	11	18	25	2	9	16	23	30	6	13
Number of Organisms:	936	738	727	285	202	96	232	97	217	733	692	390	85	768	244	425	463
ROTIFERA:																	
Asplanchna sp.		.1				1.0				.3	.1		1.2	.5	3.3	4.7	2.2
Brachionus angularis										.1			1.2			.7	2.4
Brachionus bidentata											.1			22.3	13.1	2.6	10.8
Brachionus budapestenesis	.2																
Brachionus calyciflorus	.6	3.9	8.3	24.1	16.8	10.4	70.4	62.9	8.8	75.5	74.9	23.1	35.2	18.8	1.6	1.9	13.6
Brachionus caudatus														.4		.2	
Brachionus quadridentatus											.5			4.9	14.7	1.0	1.3
Brachionus rubens										1.2					.4	1.0	
Brachionus urceolaris	33.3	72.0	57.3	37.5	10.9	2.1	.4	1.0	5.1	2.0	2.1	2.7	1.2	2.9	1.2	.7	.4
Cephalodella sp.															.4		
Euchlanis sp.		.1						1.0	1.4	.4	2.3	3.9	7.1	17.2	.4		.7
Filinia longiseta	.5	.4		.4				1.0		.6	.1		1.2				
Keratella cochlearis	.2	.1			.5				.5			.5	2.4				
Lecane luna																.7	
Lepadella sp.												.4		3.7	2.1	2.6	
Macrochaetus sp.	.2																
Monostyla sp.		.1															
Notholca striata					.5					.3		.4					
Philodina sp.				1.1	.5	3.1	.9	2.1	20.4	.4	.6	2.7	3.5	.9	.4	1.0	.4
Platyias patulus																.2	.4
Platyias quadricornis															.4	.2	
Polyarthra dolichoptera		.1								.1							1.1
Rotaria neptunia	.2							1.0	.5	1.0							
Synchaeta sp.		.1	.8	1.8	3.5	5.2	3.9	1.0	9.2	.4	.1	.8		.3		.2	.2
Testudinella sp.		.4	.4	.7			.4		.9	.1	.1	.5		.1	1.2	1.7	2.2
Trichocera sp.									.9								
Trichotria sp.					.5									.3			
Trochosphaera sp.							.4										
Unknown 2									2.3								.9
Unident. nonloricate	.4	1.6	.1		.5				4.6	.1	.5				.4	.5	2.2
CLADOCERA:																	
Alona affinis	1.7	.4	.8		1.5					.4	.4	1.0		.1	.4	.2	.2

Table 6. (continued)

Dates of Collection:	Feb. 21	Feb. 28	Mar. 7	Mar. 14	Mar. 21	Mar. 28	Apr. 4	Apr. 11	Apr. 18	Apr. 25	May 2	May 9	May 16	May 23	May 30	Jun. 6	Jun. 13
Number of Organisms:	936	738	727	285	202	96	232	97	217	733	692	390	85	768	244	425	463
COPEPODA:																	
Calanoida:																	
Copepodid		.1				1.0	.4					.4		.3		.2	
Diaptomus pallidus	.3	.1	.3	.4	.5	1.0		1.0	.5			1.3	1.2			2.1	.4
Harpacticoida:																	
Copepodid			.1														
Atthellya illinoisensis					.5				.5	.3	.1	.5					
Canthocamptus robertcokeri	.2	.1			.5							.4					
Canthocamptus sp.	.2																
Unknown 3 (Order: Caligoida)														.1			
OSTRACODA:																	
Nauplius larva	.2	.7	.3				.4		.9	.4	.1	1.3		.4	2.9	.2	
Unknown 6									.5	.1		.4			2.5	.5	
Unknown 7												.4			.4		
Unknown 8								1.0								.2	

Table 7. Percent frequency occurrence for the total zooplankton, qualitatively collected, at Site 5, on Polecat Creek, Coles County, Illinois, from 17 weekly samples, 21 Feb. to 13 Jun., 1975.

	Feb.		Mar.				Apr.				May					Jun.	
Dates of Collection:	21	28	7	14	21	28	4	11	18	25	2	9	16	23	30	6	13
Number of Organisms:	420	738	518	258	132	91	138	24	26	206	125	181	122	243	270	195	174
ROTIFERA:																	
Asplanchna sp.			.2		.8					.5		.6	4.1		1.1		4.0
Brachionus angularis																1.0	9.8
Brachionus bidentata													.8	25.5	16.7	5.1	12.1
Brachionus calyciflorus	4.1	3.3	6.6	28.7	31.0	17.6	74.0	45.7	3.8	44.6	52.8	27.1	37.0	4.9	4.1	1.0	18.3
Brachionus caudatus														1.7	2.2	1.0	
Brachionus quadridentatus											.8			3.7	23.6	1.0	2.9
Brachionus rubens						1.1				1.0	4.0				.4	1.0	
Brachionus urceolaris	65.3	71.8	65.8	30.2	10.6	3.3			3.8	7.3		2.1	2.5	2.1			.6
Cephalodella sp.																	.6
Euchlanis sp.											.8	3.3	5.7	11.1	1.1		1.2
Filinia longiseta	.7	.3	.2				.7			1.5			.8				
Keratella cochlearis		.1								.5		.6	.8	.4		.5	
Lecane luna																.5	
Lepadella sp.													.8	25.5	4.8	2.1	
Monostyla sp.	.2																
Mytillina sp.																.5	1.2
Notholca striata		.3															
Philodina sp.			.4	.4	2.3	1.1	.7	4.2	7.7	1.0	.8		1.6	.4	2.9	1.0	1.2
Platyias quadricornis				.4													
Polyarthra dolichoptera										1.0	.8						
Rotaria neptunia					.8			4.2									
Rotaria sp.										2.4							
Synchaeta sp.		.5	.6	4.6	3.8	7.7	3.7	8.3	11.6	2.9	4.0	.6					
Testudinella sp.	.7		1.4		.8				3.8			1.0		.4	.7	2.1	2.3
Unknown 2																	1.2
Unident. nonloricate	1.2	.8	.6	.4	2.3	3.3		4.2	15.5	2.9	3.2		.8	1.7		.5	.6
CLADOCERA:																	
Alona affinis	1.2	.5	.4	.4	3.0				3.8			1.0		.4	.4	.5	
Alona costa		.1	.2								.8		1.6		.4		.6
Alona guttata												.6					
Bosmina longirostris	.2	.5	2.5	.8								1.6			.4	1.5	
Chycorus sphaericus	8.4	11.8	7.9	12.0	14.3	27.4	6.5	4.2	3.8	12.0	17.6	36.0	21.4	12.3	16.3	2.1	4.0

Table 7. (continued)

Dates of Collection:	Feb. 21	28	Mar. 7	14	21	28	Apr. 4	11	18	25	May 2	9	16	23	30	Jun. 6	13
Number of Organisms:	420	738	518	258	132	91	138	24	26	206	125	181	122	243	270	195	174
OSTRACODA:																	
Nauplius larva	2.1		1.5		.8							.6	.8	.4	1.1		1.8
Unknown 6		.4	.6						3.8								
Unknown 7					1.5												.6

Table 8. Percent frequency occurrence for the total zooplankton, qualitatively collected, at Site 6, on Polecat Creek, Coles County, Illinois, from 17 weekly samples, 21 Feb. to 13 Jun., 1975.

	Feb.		Mar.				Apr.				May					Jun.	
Dates of Collection:	21	28	7	14	21	28	4	11	18	25	2	9	16	23	30	6	13
Number of Organisms:	672	376	507	124	95	126	100	9	15	206	36	175	28	372	110	121	178
ROTIFERA:																	
Asplanchna sp.														1.9	.9		13.4
Brachionus angularis													3.6	.2		.8	11.8
Brachionus bidentata														20.3	18.3	11.6	3.4
Brachionus calyciflorus	1.5	5.1	9.5	18.6	31.5	31.6	60.0	66.7	53.3	51.9	69.4	13.6	42.9	6.2		5.0	13.4
Brachionus caudatus														1.6	3.6		
Brachionus quadridentatus										.5				4.3	2.7	.8	1.1
Brachionus rubens				.8						3.9						3.3	
Brachionus urceolaris	67.2	58.7	65.6	32.2	10.5	6.4			13.3	8.6	8.3	11.3		1.6	1.8		2.3
Cephalodella sp.										.5							
Euchlanis sp.		.3		2.4						1.0	2.8	6.3	7.1	3.8			.6
Filinia longiseta	.5		.6							1.0				.2			
Keratella cochlearis		.3										1.2		1.1			
Lecane luna															6.4	4.1	
Lepadella sp.												.6		20.3	1.8	1.7	
Monostyla sp.		.3															
Mytillina sp.																.8	
Notholca striata										.5							
Philodina sp.				1.6	5.3	.8	1.0					.6				1.7	.6
Polyarthra dolichoptera	.3									.5			3.6				
Rotaria neptunia	.2	.3	.4							1.0							
Synchaeta sp.			1.4	2.4	1.1	11.1	2.0	11.1		2.0	2.8		3.6	.2			
Testudinella sp.															.9	2.5	2.8
Trichotria sp.										.5							
Unknown 1		.8															
Unident. nonloricate	.9	.5				2.4				6.3	2.8	1.2		.2	1.8		1.1
CLADOCERA:																	
Alona affinis	.7	1.9	.4	1.6	1.1		1.0					1.7		.2		2.5	
Alona costa			.2		1.1									1.6			
Alona guttata												1.7					
Bosmina longirostris	.2		.8									.6		.2	3.6	.8	
Chydorus sphaericus	2.2	10.5	6.1	12.1	6.3	16.7	9.0		20.0	5.8	5.6	17.7	21.4	15.3	26.4	2.5	3.4

Table 8. (continued)

Dates of Collection:	Feb. 21	Feb. 28	Mar. 7	Mar. 14	Mar. 21	Mar. 28	Apr. 4	Apr. 11	Apr. 18	Apr. 25	May 2	May 9	May 16	May 23	May 30	Jun. 6	Jun. 13
Number of Organisms:	672	376	507	124	95	126	100	9	15	206	36	175	28	372	110	121	178
CLADOCERA:																	
Ceriodaphnia reticulata																.8	.6
Ceriodaphnia sp.			.2			.8											
Daphnia longispina												1.2		1.1	5.4	8.3	2.3
Daphnia pulex												1.2		.2			1.1
Diaphanosoma brachyurum																1.7	3.4
Ilyocryptus spinifer												.6				.8	
Moina brachiata																9.9	1.1
Moina micrura												1.7				1.7	.6
Pleuroxus denticulatus												.6			1.8		
Scapholeberis kingi															1.8		
Unident. Cladocera																.8	
COPEPODA:																	
Nauplius larva	14.4	11.4	10.4	20.2	21.1	20.6	20.0	11.1	6.7	7.8	8.3	13.1	7.1	16.7	18.3	19.8	30.2
Cyclopoida:																	
Copepodid	10.1	7.7	3.8	5.7	17.8	4.0	5.0	11.1	6.7	7.2		21.5	7.1	2.2	1.8	9.9	1.7
Cyclops bicuspidatus													3.6				
Eucyclops agilis	.6	.8	.2	1.6	2.1	.8						.6				3.2	1.1
Paracyclops fimbiratus										1.0							
Mesocyclops edax						.8											1.7
Calanoida:																	
Copepodid	.2		.2									.6		.2		1.7	
Diaptomus pallidus	.5	.3		.8		.8	1.0					.6			.9	3.3	2.3
Harpacticoida:																	
Copepodid		.3										.6					
Attheyella illinoisensis							1.0					.6					
Canthocamptus robertcokeri						.8											
OSTRACODA:																	
Nauplius larva	.3	.8	.2		2.1	2.4						.6		.2	1.8		

Table 9. Percent frequency occurrence for the total zooplankton, quantitatively collected, at Site 1, on Polecat Creek, Coles County, Illinois, from 11 samples, 4 Apr. to 13 Jun., 1975. The percentage figures were computed from the sum of two replicate samples, each consisting of 200 liters of water poured through a No. 20 plankton net.

	Apr.				May					Jun.	
Dates of Collection:	4	11	18	25	2	9	16	23	30	6	13
Number of Organisms:	4	4	17	144	5	40	4	12	7	17	6
ROTIFERA:											
Brachionus angularis										11.8	
Brachionus bidentata				.7							
Brachionus calyciflorus				9.7		10.0					16.7
Brachionus urceolaris				.7							
Cephalodella sp.					20.0	15.0	25.0				
Filinia longiseta				13.1		12.5			14.3		
Keratella cochlearis			5.9	1.4		2.5					16.7
Keratella valga				6.3	20.0						
Lepadella sp.				.7				83.4			
Notholca striata		25.0	11.7	2.1							
Philodina sp.	25.0	25.0		30.5		10.0	25.0	8.3	28.5	11.8	
Platyias quadricornis										5.9	
Polyarthra dolichoptera				2.8							
Rotaria neptunia			5.9								
Synchaeta sp.				2.1	20.0	2.5					16.7
Trichocerca sp.				1.4							
Unknown 1				.7						5.9	
Unknown 2			47.2	13.2	20.0	2.5	25.0				
Unident. nonloricate	50.0		11.7	2.8		5.0		8.3			16.7
CLADOCERA:											
Chydorus sphaericus				1.4		10.0			14.3		
COPEPODA:											
Nauplius larva	25.0	25.0	11.7	9.0		7.5	25.0		28.6	41.0	16.7
Cyclopoida:											
Copepodid			5.9			10.0			14.3	11.8	
Eucyclops agilis						5.0					16.7
Harpacticoida:											
Copepodid					20.0						
Canthocamptus robertcokeri										5.9	

Table 9. (continued)

	Apr.				May					Jun.	
Dates of Collection:	4	11	18	25	2	9	16	23	30	6	13
Number of Organisms:	4	4	17	144	5	40	4	12	7	17	6
OSTRACODA:											
Nauplius larva				.7		2.5				5.9	
Unknown 6		25.0				5.0					
Unknown 8				.7							

Table 10. Percent frequency occurrence for the total zooplankton, quantitatively collected, at Site 5, on Polecat Creek, Coles County, Illinois, from 11 samples, 4 Apr. to 13 Jun., 1975. The percentage figures were computed from the sum of two replicate samples, each consisting of 200 liters of water poured through a No. 20 plankton net.

	Apr.				May					Jun.	
Dates of Collection:	4	11	18	25	2	9	16	23	30	6	13
Number of Organisms:	19	9	26	28	11	10	5	44	68	11	11
ROTIFERA:											
Brachionus bidentata								18.2	19.1	9.1	
Brachionus calyciflorus	26.3	22.2	7.6	21.5	45.4	10.0		4.5	1.5		45.5
Brachionus caudatus								2.3	1.5		
Brachionus quadridentatus								6.8	13.2		9.1
Brachionus rubens										9.1	
Brachionus urceolaris				3.6							
Filinia longiseta							20.0	4.5			
Keratella cochlearis						10.0		2.3			
Lepadella sp.								15.9	1.5		
Notholca striata				3.6							
Philodina sp.	5.3		7.6	7.1	9.1			11.4	8.8		
Polyarthra dolichoptera					9.1	10.0				9.1	
Rotaria neptunia			3.9	3.6							
Synchaeta sp.			3.9		18.2						
Testudinella sp.											9.1
Trichocera sp.							40.0				
Unknown 1			3.9	7.1							
Unknown 2		22.2	42.3	14.3		10.0			2.9		
Unident. nonloricate	10.5	11.1	7.6	7.1	9.1						
CLADOCERA:											
Alona affinis	5.3								2.9	9.1	
Alona costa								2.3	2.9		
Chydorus sphaericus	10.5		3.9	7.1	9.1	20.0		18.2	23.6	9.1	
Daphnia longispina						10.0				9.1	
Daphnia pulex										9.1	
Daphnia sp.									1.5		
Scapholeberis kingi											9.1

Table 10. (continued)

Dates of Collection:	Apr. 4	11	18	25	May 2	9	16	23	30	Jun. 6	13
Number of Organisms:	19	9	26	28	11	10	5	44	68	11	11
COPEPODA:											
Nauplius larva	42.2	44.5	15.4	7.1		10.0	40.0	9.1	13.2	9.1	18.1
Cyclopoida:											
Copepodid				7.1				4.5	5.9	9.1	
Eucyclops agilis				3.6		10.0					
Mesocyclops edax						10.0					
Calanoida:											
Diaptomus pallidus										18.1	
Harpacticoida:											
Attheyella illinoisensis											9.1
OSTRACODA:											
Nauplius larva									1.5		
Unknown 7				3.6							
Unknown 8			3.9								

Table 11. Percent frequency occurrence for the total zooplankton, quantitatively collected, at Site 6, on Polecat Creek, Coles County, Illinois, from 11 samples, 4 Apr. to 13 Jun., 1975. The percentage figures were computed from the sum of two replicate samples, each consisting of 200 liters of water poured through a No. 20 plankton net.

Dates of Collection:	Apr.				May					Jun.	
	4	11	18	25	2	9	16	23	30	6	13
Number of Organisms:	44	4	16	38	14	13	9	16	35	26	43
ROTIFERA:											
Asplanchna sp.						7.7		6.2			2.3
Brachionus angularis											4.7
Brachionus bidentata								25.0	2.9	3.9	4.7
Brachionus calyciflorus	27.3	50.0	31.1	21.1	43.0	7.7		6.2	2.9		2.3
Brachionus caudatus								6.2	2.9		
Brachionus quadridentatus									2.9		2.3
Brachionus rubens				2.6							
Brachionus urceolaris		25.0	6.3	2.6	7.1						
Cephalodella sp.				5.3	7.1						
Filinia longiseta	2.3			2.6			11.1			3.9	
Keratella cochlearis				2.6		7.7		18.8			
Lecane luna									5.6	3.9	2.3
Lepadella sp.	2.3								2.9		
Philodina sp.	11.4				21.4			12.4	14.2		11.6
Polyarthra dolichoptera	6.8			10.5					2.9	3.9	7.0
Rotaria neptunia	6.8										
Synchaeta sp.			12.5	5.3	7.1						23.3
Testudinella sp.									2.9	3.9	
Trichocera sp.							33.3			3.9	4.7
Unknown 1							11.1		14.2		
Unknown 2	9.1		12.5	18.5					2.9	3.9	2.3
Unident. nonloricate	15.9		12.5	2.6		7.7				7.6	13.9
CLADOCERA:											
Alona affinis							11.1				
Bosmina longirostris									2.9	3.9	
Chydorus sphaericus	2.3		6.3	2.6		15.4	11.1	18.8			
Daphnia longispina									2.9	3.9	
Daphnia pulex										7.6	
Diaphanosoma brachyurum										7.6	
Scapholeberis kingi									2.9		2.3

Table 11. (continued)

	Apr.				May					Jun.	
Dates of Collection:	4	11	18	25	2	9	16	23	30	6	13
Number of Organisms:	44	4	16	38	14	13	9	16	35	26	43
COPEPODA:											
Nauplius larva	15.8	25.0	6.3	21.1	14.3	30.7	22.3	6.2	31.2	30.6	16.3
Cyclopoida:											
Copepodid			12.5	2.6		7.7				7.6	
Cyclops sp.						7.7					
Eucyclops agilis						7.7			2.9		
Calanoid											
Diaptomus pallidus										3.9	

Fig. 14. Periodicity of each dominant Rotifera, Cladocera, Copepoda, and Ostracoda, and overall, predominant zooplankter for each weekly collection from Polecat Creek, Site 1 (N. E. $\frac{1}{4}$, Sec. 8, T. 12 N., R. 10 E.), Coles County, Illinois, during spring, 1975. Qualitative collections were made weekly by suspending a No. 12 plankton net in the current for a calculated 10,000-liter volume. Explanation: a heavy line (▬▬) indicates the dominant member for each of the major taxonomic groups (Rotifera, Cladocera, Copepoda, Ostracoda), dotted lines (┄┄) designate the two or more organisms which have equal abundance in instances in which there is an absence of a dominant group member, and a heavy line enclosed in a rectangle (▭) denotes the overall, predominant zooplankter for the entire fauna, for each weekly collection.

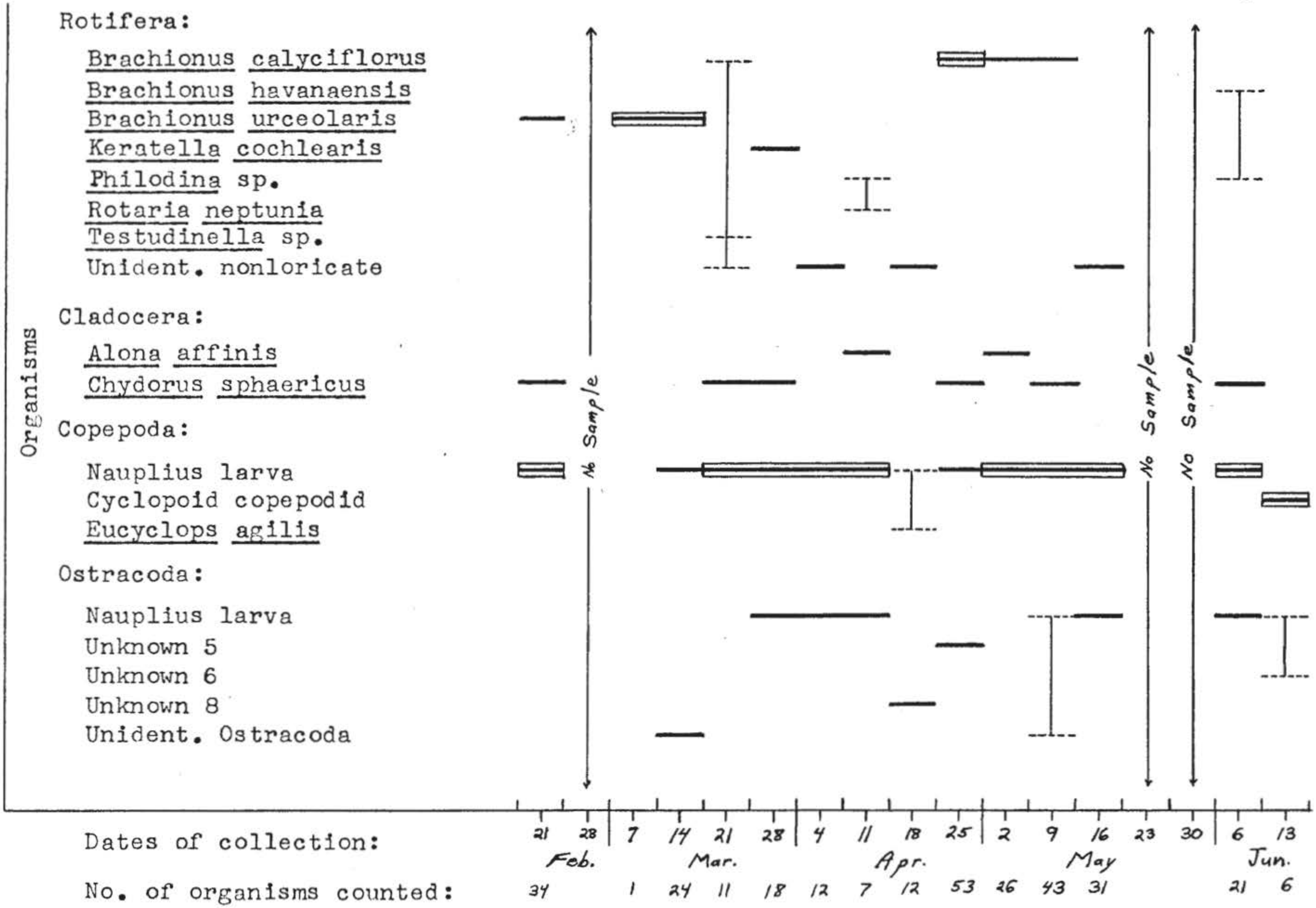

Organisms
Rotifera:
Brachionus calyciflorus
Brachionus havanaensis
Brachionus urceolaris
Keratella cochlearis
Philodina sp.
Rotaria neptunia
Testudinella sp.
Unident. nonloricate
Cladocera:
Alona affinis
Chydorus sphaericus
Copepoda:
Nauplius larva
Cyclopoid copepodid
Eucyclops agilis
Ostracoda:
Nauplius larva
Unknown 5
Unknown 6
Unknown 8
Unident. Ostracoda
No Sample
No Sample
No Sample
Dates of collection:
21 28 7 14 21 28 4 11 18 25 2 9 16 23 30 6 13
Feb. Mar. Apr. May Jun.
No. of organisms counted:
34 1 24 11 18 12 7 12 53 26 43 31 21 6

Fig. 15. Periodicity of each dominant Rotifera, Cladocera, Copepoda, and Ostracoda, and overall, predominant zooplankter for each weekly collection from Polecat Creek, Site 2 (N. E. $\frac{1}{4}$, Sec. 9, T. 12 N., R. 10 E.), Coles County, Illinois, during spring, 1975. Qualitative collections were made weekly by suspending a No. 12 plankton net in the current for a calculated 10,000-liter volume. Explanation: a heavy line (▬▬) indicates the dominant member for each of the major taxonomic groups (Rotifera, Cladocera, Copepoda, Ostracoda), dotted lines (┄┄┄) designate the two or more organisms which have equal abundance in instances which there is an absence of a dominant group member, and a heavy line enclosed in a rectangle (▭) denotes the overall, predominant zooplankter for the entire fauna, for each weekly collection.

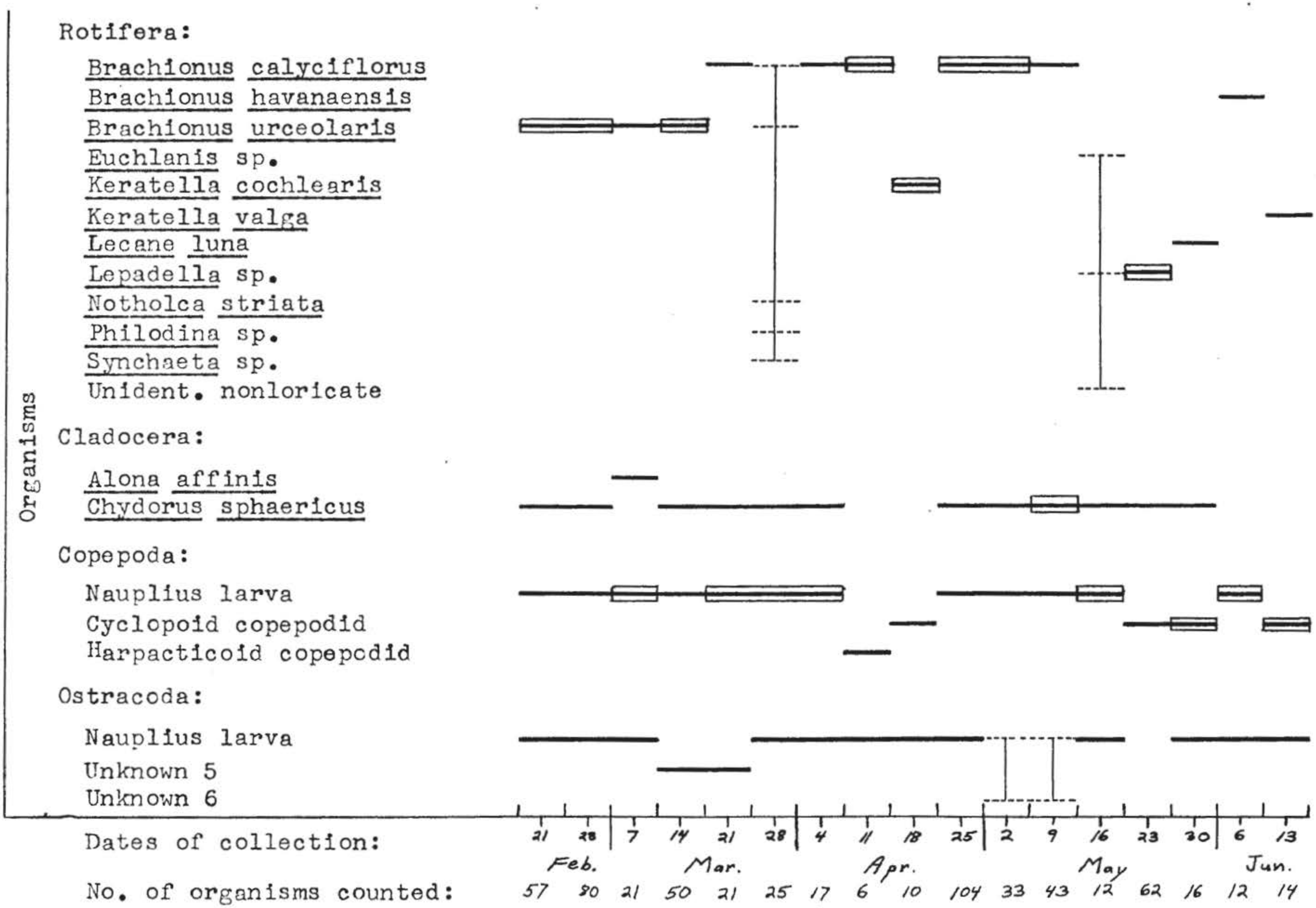

Organisms
Rotifera:
Brachionus calyciflorus
Brachionus havanaensis
Brachionus urceolaris
Euchlanis sp.
Keratella cochlearis
Keratella valga
Lecane luna
Lepadella sp.
Notholca striata
Philodina sp.
Synchaeta sp.
Unident. nonloricate
Cladocera:
Alona affinis
Chydorus sphaericus
Copepoda:
Nauplius larva
Cyclopoid copepodid
Harpacticoid copepodid
Ostracoda:
Nauplius larva
Unknown 5
Unknown 6
Dates of collection: 21 28 7 14 21 28 4 11 18 25 2 9 16 23 30 6 13
Feb. Mar. Apr. May Jun.
No. of organisms counted: 57 80 21 50 21 25 17 6 10 104 33 43 12 62 16 12 14

Fig. 16. Periodicity of each dominant Rotifera, Cladocera, Copepoda, and Ostracoda, and overall, predominant zooplankter for each weekly collection from Polecat Creek, Site 3 (N. E. $\frac{1}{4}$, Sec. 2, T. 12 N., R. 10 E.), Coles County, Illinois, during spring, 1975. Qualitative collections were made weekly by suspending a No. 12 plankton net in the current for a calculated 10,000-liter volume. Explanation: a heavy line (▬▬) indicates the dominant member for each of the major taxonomic groups (Rotifera, Cladocera, Copepoda, Ostracoda), dotted lines (┈┈) designate the two or more organisms which have equal abundance in instances in which there is an absence of a dominant group member, and a heavy line enclosed in a rectangle (▭) denotes the overall, predominant zooplankter for the entire fauna, for each weekly collection.

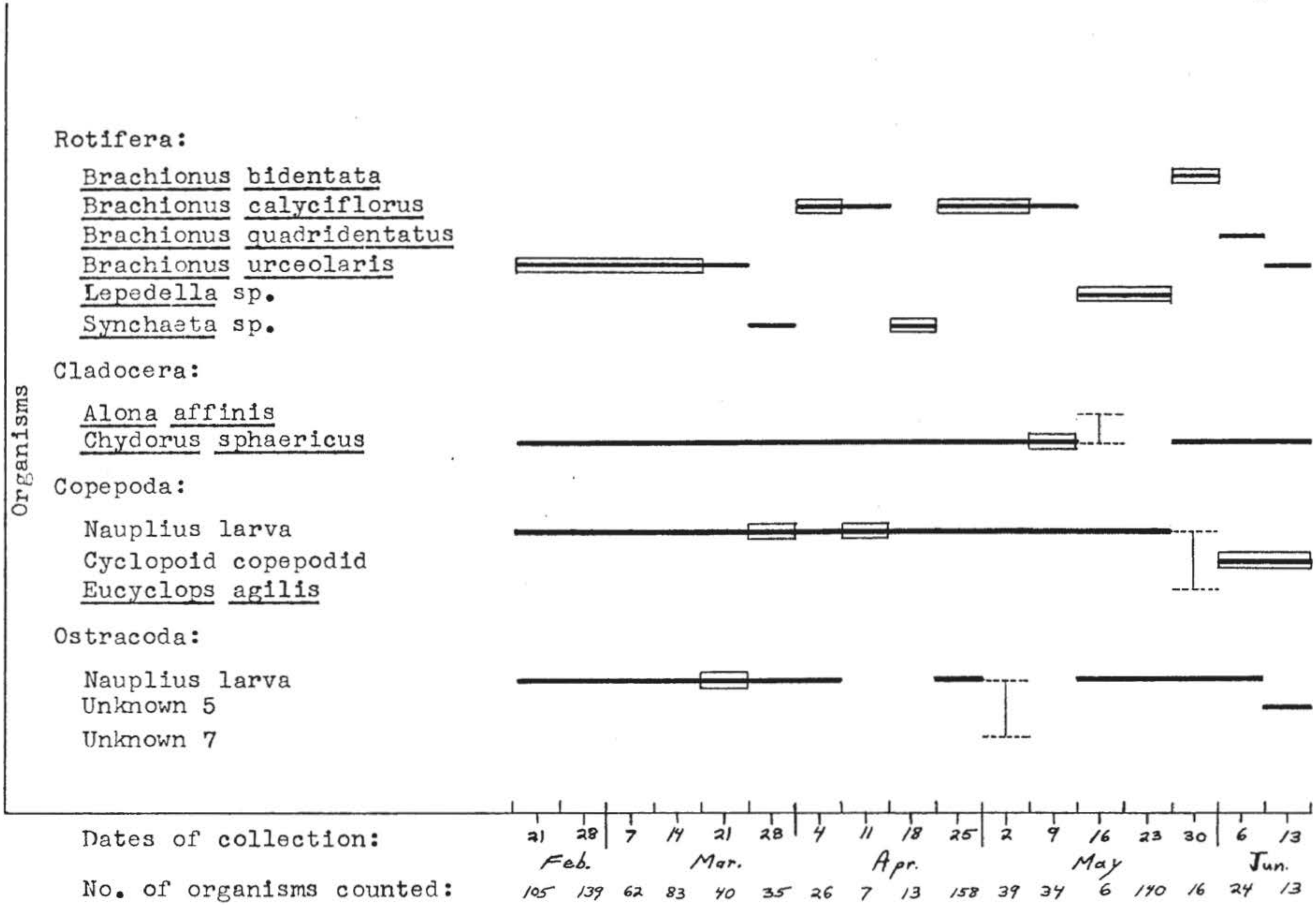

Organisms
Rotifera:
Brachionus bidentata
Brachionus calyciflorus
Brachionus quadridentatus
Brachionus urceolaris
Lepedella sp.
Synchaeta sp.
Cladocera:
Alona affinis
Chydorus sphaericus
Copepoda:
Nauplius larva
Cyclopoid copepodid
Eucyclops agilis
Ostracoda:
Nauplius larva
Unknown 5
Unknown 7
Dates of collection: 21 28 7 14 21 28 4 11 18 25 2 9 16 23 30 6 13
Feb. Mar. Apr. May Jun.
No. of organisms counted: 105 139 62 83 40 35 26 7 13 158 39 34 6 140 16 24 13

Fig. 17. Periodicity of each dominant Rotifera, Cladocera, Copepoda, and Ostracoda, and overall, predominant zooplankter for each weekly collection from Polecat Creek, Site 4 (N. E. $\frac{1}{4}$, Sec. 1, T. 12 N., R. 10 E), Coles County, Illinois, during spring, 1975. Qualitative collections were made weekly by suspending a No. 12 plankton net in the current for a calculated 10,000-liter volume. Explanation: a heavy line (▬▬) indicates the dominant member for each of the major taxonomic groups (Rotifera, Cladocera, Copepoda, Ostracoda), dotted lines (┈┈) designate the two or more organisms which have equal abundance in instances in which there is an absence of a dominant group member, and a heavy line enclosed in a rectangle (▭) denotes the overall, predominant zooplankter for the entire fauna, for each weekly collection.

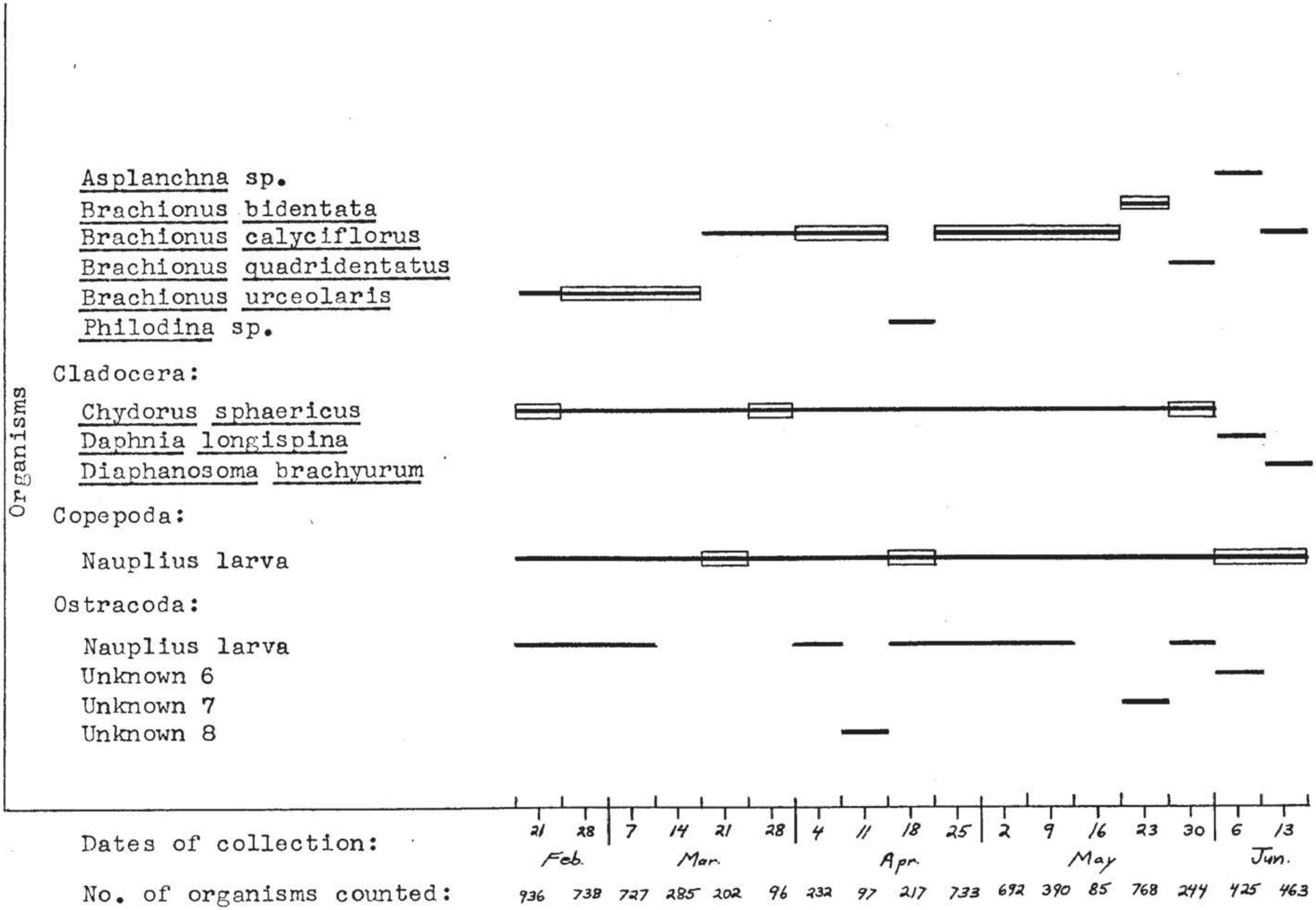
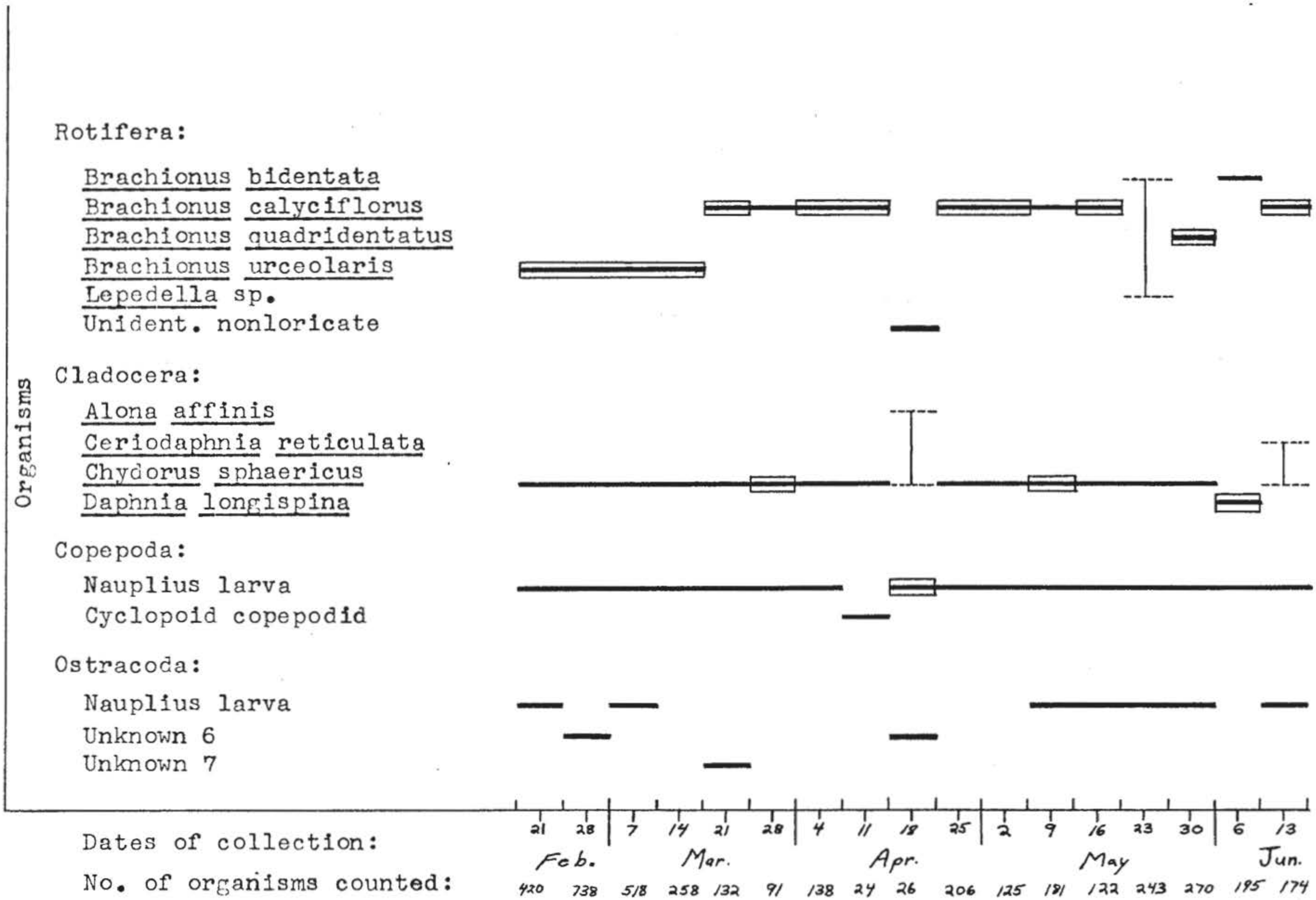

Organisms
Asplanchna sp.
Brachionus bidentata
Brachionus calyciflorus
Brachionus quadridentatus
Brachionus urceolaris
Philodina sp.
Cladocera:
Chydorus sphaericus
Daphnia longispina
Diaphanosoma brachyurum
Copepoda:
Nauplius larva
Ostracoda:
Nauplius larva
Unknown 6
Unknown 7
Unknown 8
Dates of collection:
21 28 7 14 21 28 4 11 18 25 2 9 16 23 30 6 13
Feb. Mar. Apr. May Jun.
No. of organisms counted:
936 738 727 285 202 96 232 97 217 733 692 390 85 768 244 425 463

Fig. 18. Periodicity of each dominant Rotifera, Cladocera, Copepoda, and Ostracoda, and overall, predominant zooplankter for each weekly collection from Polecat Creek, Site 5 (N. W. $\frac{1}{4}$, Sec. 6, T. 12 N., R. 11 E.), Coles County, Illinois, during spring, 1975. Qualitative collections were made weekly by suspending a No. 12 plankton net in the current for a calculated 10,000-liter volume. Explanation: a heavy line ( ) indicates the dominant member for each of the major taxonomic groups (Rotifera, Cladocera, Copepoda, Ostracoda), dotted lines ( ) designate the two or more organisms which have equal abundance in instances in which there is an absence of a dominant group member, and a heavy line enclosed in a rectangle ( ) denotes the overall, predominant zooplankter for the entire fauna, for each weekly collection.



Organisms
Rotifera:
Brachionus bidentata
Brachionus calyciflorus
Brachionus quadridentatus
Brachionus urceolaris
Lepedella sp.
Unident. nonloricate
Cladocera:
Alona affinis
Ceriodaphnia reticulata
Chydorus sphaericus
Daphnia longispina
Copepoda:
Nauplius larva
Cyclopoid copepodid
Ostracoda:
Nauplius larva
Unknown 6
Unknown 7
Dates of collection:
21 28 7 14 21 28 4 11 18 25 2 9 16 23 30 6 13
Feb. Mar. Apr. May Jun.
No. of organisms counted:
420 738 518 258 132 91 138 24 26 206 125 181 122 243 270 195 174

Fig. 19. Periodicity of each dominant Rotifera, Cladocera, Copepoda, and Ostracoda, and overall, predominant zooplankter for each weekly collection from Polecat Creek, Site 6 (N. W. $\frac{1}{4}$, Sec. 6, T. 12 N., R. 11 E.), Coles County, Illinois, during spring, 1975. Qualitative collections were made weekly by suspending a No. 12 plankton net in the current for a calculated 10,000-liter volume. Explanation: a heavy line (▬▬) indicates the dominant member for each of the major taxonomic groups (Rotifera, Cladocera, Copepoda, and Ostracoda), dotted lines (┄┄) designate the two or more organisms which have equal abundance in instances in which there is an absence of a dominant group member, and a heavy line enclosed in a rectangle (▭) denotes the overall, predominant zooplankter for the entire fauna, for each weekly collection.

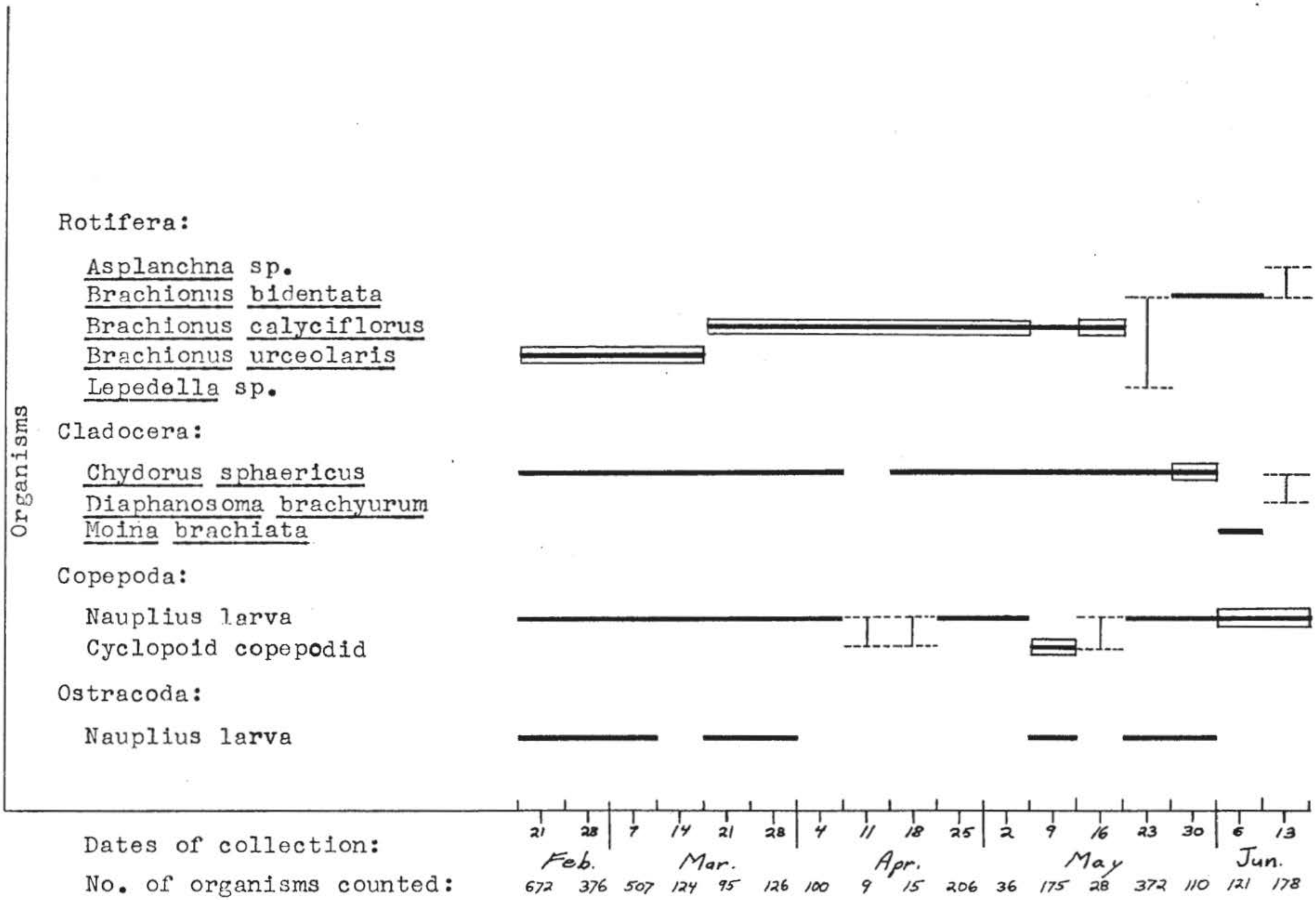

Organisms
Rotifera:
Asplanchna sp.
Brachionus bidentata
Brachionus calyciflorus
Brachionus urceolaris
Lepedella sp.
Cladocera:
Chydorus sphaericus
Diaphanosoma brachyurum
Moina brachiata
Copepoda:
Nauplius larva
Cyclopoid copepodid
Ostracoda:
Nauplius larva
Dates of collection:
21 28 7 14 21 28 4 11 18 25 2 9 16 23 30 6 13
Feb. Mar. Apr. May Jun.
No. of organisms counted:
672 376 507 124 95 126 100 9 15 206 36 175 28 372 110 121 178

Fig. 20. Periodicity of each dominant Rotifera, Cladocera, Copepoda, and Ostracoda, and overall, predominant zooplankter for each weekly collection from Polecat Creek, Site 1 (N. E. $\frac{1}{4}$, Sec. 8, T. 12 N., R. 10 E.), Coles County, Illinois, during spring, 1975. Quantitative collections were made by pouring 200 liters of water through a No. 20 plankton net. Explanation: a heavy line (▬) indicates the dominant member for each of the major taxonomic groups (Rotifera, Cladocera, Copepoda, Ostracoda), dotted lines (┅) designate the two or more organisms that have equal abundance in instances in which there is an absence of a dominant group member, and a heavy line enclosed in a rectangle (▣) denotes the overall, predominant zooplankter for the entire fauna, for each weekly collection.

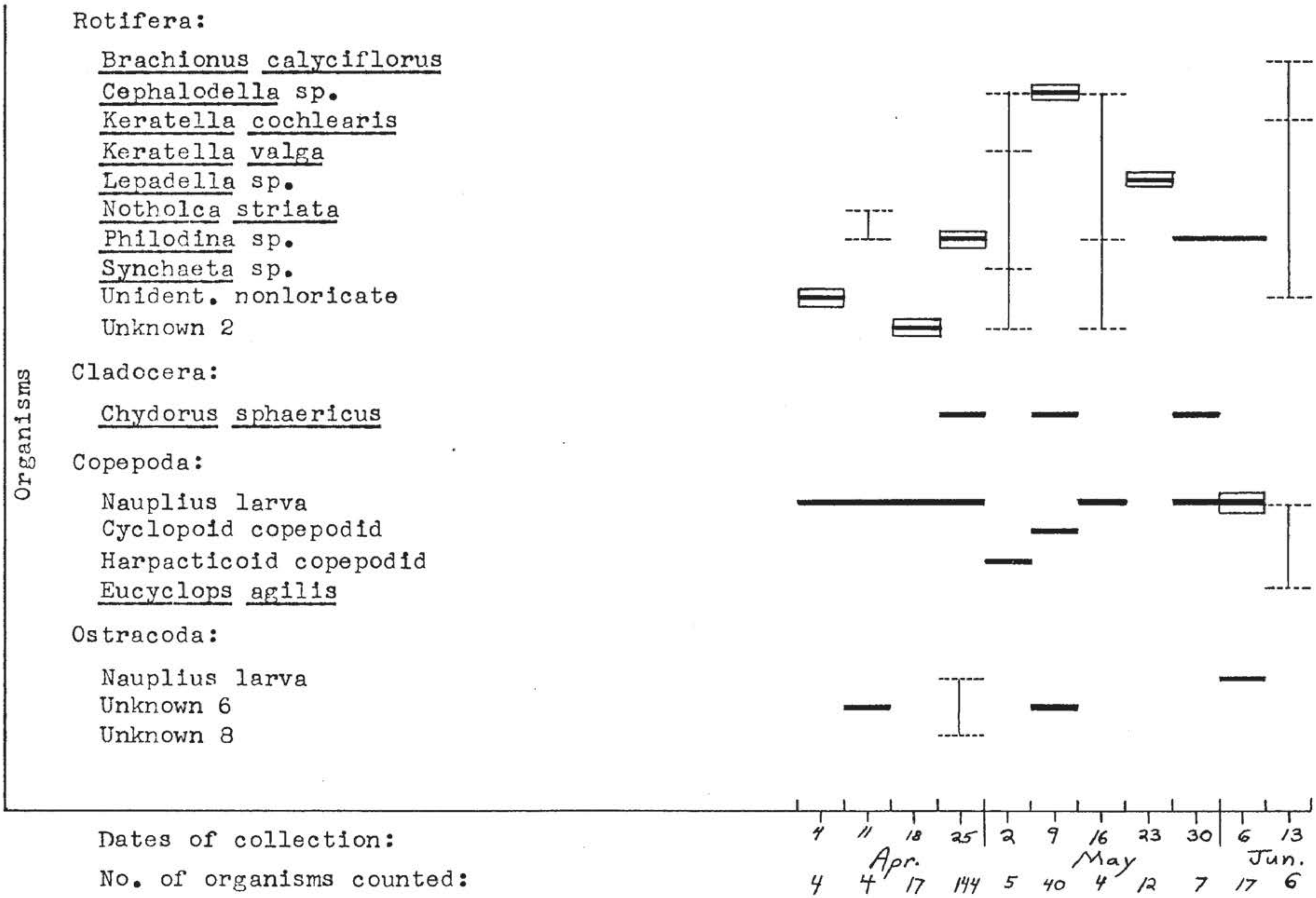

Organisms
Rotifera:
Brachionus calyciflorus
Cephalodella sp.
Keratella cochlearis
Keratella valga
Lepadella sp.
Notholca striata
Philodina sp.
Synchaeta sp.
Unident. nonloricate
Unknown 2
Cladocera:
Chydorus sphaericus
Copepoda:
Nauplius larva
Cyclopoid copepodid
Harpacticoid copepodid
Eucyclops agilis
Ostracoda:
Nauplius larva
Unknown 6
Unknown 8
Dates of collection:
4 11 18 25 2 9 16 23 30 6 13
Apr. May Jun.
No. of organisms counted:
4 4 17 144 5 40 4 12 7 17 6

Fig. 21. Periodicity of each dominant Rotifera, Cladocera, Copepoda, and Ostracoda, and overall, predominant zooplankter for each weekly collection from Polecat Creek, Site 5 (N. W. $\frac{1}{4}$, Sec. 6, T. 12 N., R. 11 E.), Coles County, Illinois, during spring, 1975. Quantitative collections were made by pouring 200 liters of water through a No. 20 plankton net. Explanation: a heavy line (▬) indicates the dominant member for each of the major taxonomic groups (Rotifera, Cladocera, Copepoda, Ostracoda), dotted lines (┅┅) designate the two or more organisms that have equal abundance in instances in which there is an absence of a dominant group member, and a heavy line enclosed in a rectangle (▣) denotes the overall, predominant zooplankter for the entire fauna, for each weekly collection.

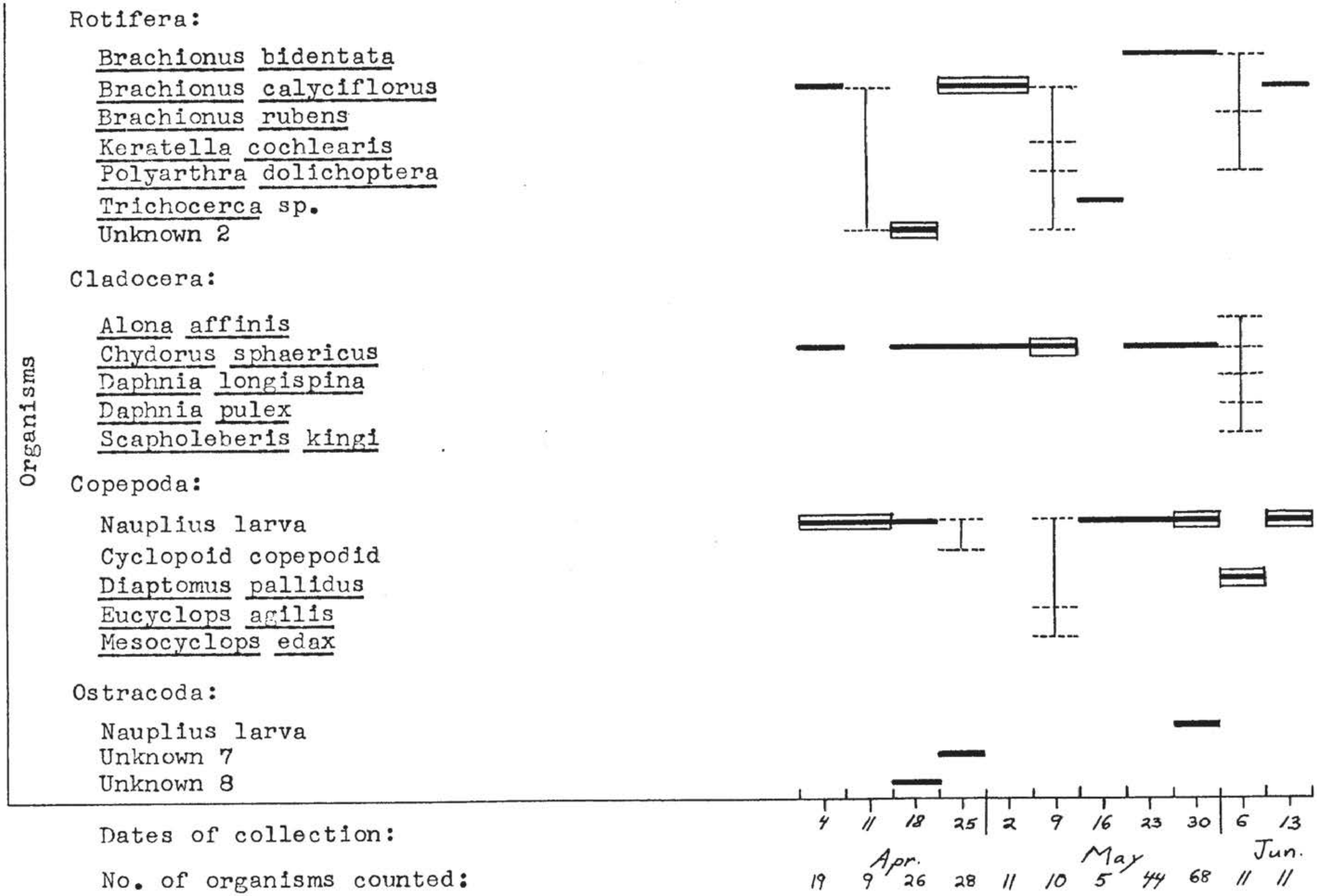

Organisms
Rotifera:
Brachionus bidentata
Brachionus calyciflorus
Brachionus rubens
Keratella cochlearis
Polyarthra dolichoptera
Trichocerca sp.
Unknown 2
Cladocera:
Alona affinis
Chydorus sphaericus
Daphnia longispina
Daphnia pulex
Scapholeberis kingi
Copepoda:
Nauplius larva
Cyclopoid copepodid
Diaptomus pallidus
Eucyclops agilis
Mesocyclops edax
Ostracoda:
Nauplius larva
Unknown 7
Unknown 8
Dates of collection:
4 11 18 25 2 9 16 23 30 6 13
Apr. May Jun.
No. of organisms counted:
19 9 26 28 11 10 5 44 68 11 11

Fig. 22. Periodicity of each dominant Rotifera, Cladocera, Copepoda, and Ostracoda, and overall, predominant zooplankter for each weekly collection from Polecat Creek, Site 6 (N. W. $\frac{1}{4}$, Sec. 6, T. 12 N., R. 11 E.), Coles County, Illinois, during spring, 1975. Quantitative collections were made by pouring 200 liters of water through a No. 20 plankton net. Explanation: a heavy line ( ) indicates the dominant member for each of the major taxonomic groups (Rotifera, Cladocera, Copepoda, Ostracoda), dotted lines ( ) designate the two or more organisms that have equal abundance in instances in which there is an absence of a dominant group member, and a heavy line enclosed in a rectangle ( ) denotes the overall, predominant zooplankter for the entire fauna, for each weekly collection.

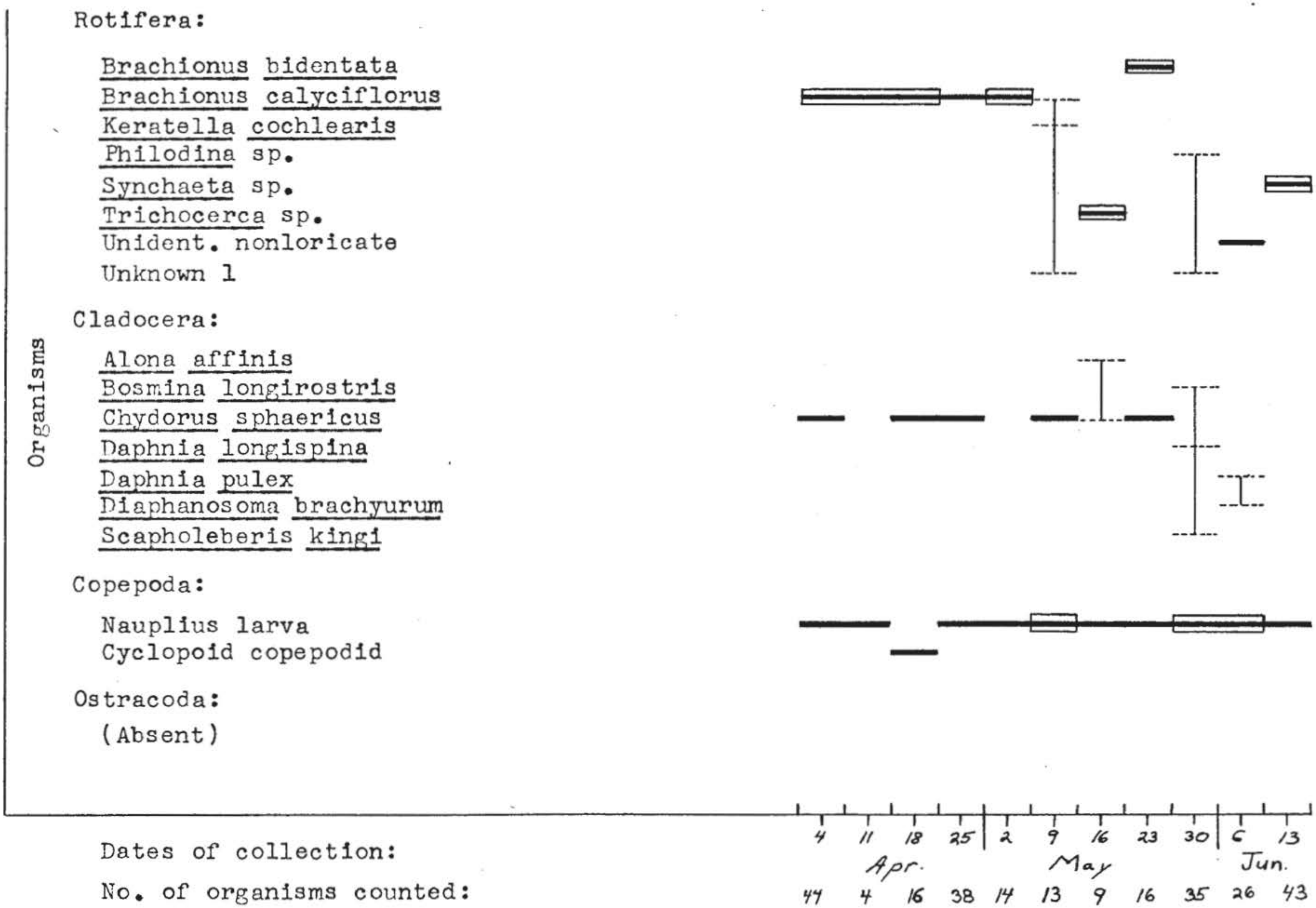

Rotifera:
Brachionus bidentata
Brachionus calyciflorus
Keratella cochlearis
Philodina sp.
Synchaeta sp.
Trichocerca sp.
Unident. nonloricate
Unknown 1
Cladocera:
Alona affinis
Bosmina longirostris
Chydorus sphaericus
Daphnia longispina
Daphnia pulex
Diaphanosoma brachyurum
Scapholeberis kingi
Copepoda:
Nauplius larva
Cyclopoid copepodid
Ostracoda:
(Absent)
Organisms
Dates of collection:
4 11 18 25 2 9 16 23 30 6 13
Apr. May Jun.
No. of organisms counted:
44 4 16 38 14 13 9 16 35 26 43

Table 12. Percent frequency occurrence for Rotifera, Cladocera, Copepoda, and Ostracoda for Sites 1 - 6 on Polecat Creek, Coles County, Illinois. Numeric values are derived from the combined weekly samples, qualitatively collected, for each respective site. Collections were taken on a weekly basis[1] from Feb. 21 to Jun. 13, 1975.

	Sites					
	1	2	3	4	5	6
No. of organisms:	299	579	940	7330	3861	3250
Rotifera:	42.4	45.6	49.7	54.2	59.2	60.2
Cladocera:	8.0	10.9	15.6	18.1	18.1	14.9
Copepoda:	42.0	33.2	27.1	26.4	21.8	24.4
Ostracoda:	7.6	10.3	7.6	1.3	.9	.5

[1]No qualitative collections were taken at Site 1 on Feb. 28, May 23, and 30, due to flooding.

Table 13. Comparison of percent frequency occurrence values for Rotifera, Cladocera, Copepoda, and Ostracoda as calculated from qualitative and quantitative methods of sampling. Quantitative collections were made at Sites 1, 5, and 6 on Polecat Creek, Coles County, Illinois, from 4 Apr. to 13 Jun., 1975, and compared to qualitative collections which were taken simultaneously. The numeric values are derived from the combined weekly[1] samples for each respective site.

Sites:	1	1	5	5	6	6
No. of Organisms:	211	260	1704	242	1350	258
Method of Coll.:	Qual.	Quant.	Qual.	Quant.	Qual.	Quant.
Rotifera:	36.1	68.7	56.7	58.4	59.2	66.0
Cladocera:	7.4	2.3	20.5	14.8	17.2	9.0
Copepoda:	47.6	25.4	22.0	26.0	23.4	25.0
Ostracoda:	8.9	3.6	.8	.8	.2	0.0

[1]No qualitative collections were taken at Site 1, on May 23, and 30, due to flooding.

Table 14. Number of zooplankton organisms per 100 liters of water at Sites 1, 5, and 6 on Polecat Creek, Coles County, Illinois, from Apr. 4, to Jun. 13, 1975. The quantitative calculations were computed from the examination of two replicate samples, each consisting of 200 liters of water poured through a No. 20 plankton net. Counting was done with a Sedgwick-Rafter counting chamber, conducting three survey counts per replicate sample. Also indicated are the percentage decrease from one site to another and the direction of decrease.

	Site 1		Site 5		Site 6
Date of coll.	No./100 l.	% Dec.	No./100 l.	% Dec.	No./100 l.
4 Apr.	24	← 78%	107	← 59%	260
11 Apr.	26	← 58%	62	→ 63%	23
18 Apr.	111	← 31%	161	→ 42%	93
25 Apr.	924	→ 81%	176	← 27%	241
2 May	32	← 62%	85	← 11%	95
9 May	312	→ 77%	73	← 23%	95
16 May	26	← 30%	37	← 46%	68
23 May	77	← 77%	335	→ 66%	115
30 May	55	← 88%	448	← 2%	459
6 Jun.	131	→ 38%	81	← 56%	185
13 Jun.	45	← 42%	77	← 73%	281
Mean:	160	→ 7%	149	← 14%	230

Table 15. Number of different zooplankton species occurring at Sites 1, 2, 3, 4, 5, and 6, on Polecat Creek, Coles County, Illinois, from 21 Feb. to Jun. 13, 1975. Numeric values occurring without parentheses were derived from qualitatively collected samples. Values which appear in parentheses were derived from quantitatively collected samples, involving 200 liter samples.

Dates of Collection	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
21 Feb.	7	10	17	18	14	14
28 Feb.	*	10	10	21	20	16
7 Mar.	1	5	7	15	19	15
14 Mar.	6	12	10	11	14	12
21 Mar.	7	9	7	16	15	11
28 Mar.	6	11	13	10	10	14
4 Apr.	7 (3)	8	8	13	8 (6)	9 (10)
11 Apr.	6 (3)	3	4	15	11 (4)	4 (3)
18 Apr.	9 (7)	5	7	21	12 (10)	5 (8)
25 Apr.	12 (19)	16	17	26	17 (14)	17 (13)
2 May	10 (5)	15	9	20	14 (6)	7 (6)
9 May	13 (14)	14	9	28	18 (9)	24 (9)
16 May	8 (4)	8	5	14	18 (3)	9 (6)
23 May	* (3)	4	5	24	17 (12)	23 (8)
30 May	* (5)	7	9	26	26 (14)	18 (16)
6 Jun.	11 (8)	5	12	43	29 (10)	25 (15)
13 Jun.	4 (6)	5	7	32	29 (6)	22 (14)

*No qualitative collections were taken on Feb. 28, May 23, and 30, due to flooding at Site 1.

Table 16. Diversity indices for the zooplankton of Polecat Creek, Sites 1 - 6, Coles County, Illinois, from weekly collections, February 21 to June 13, 1975. Numeric values are derived from the combined, qualitative collections taken during February, March, April, May, and June respectively. The equation used in computing the below indices was $D = -\sum p_1 \log_2 p_1$ (Margalef, 1968) in which "p_1" equals the relative abundance, expressed as a decimal fraction, of each organism occurring in the sample, and "D" equals the diversity index. Since the equation uses $\log_2$, "D" is expressed in "bits" (ie. binary units). The total number of organisms encountered in each combined sample is given in parentheses.

Month of coll.:	Feb.	Mar.	Apr.	May	Jun.
No. of weekly coll. included:	2	4	4	5	2
Site 1	2.13* (34)	2.92 (54)	3.59 (84)	3.10* (100)	3.04 (27)
Site 2	2.13 (137)	3.21 (117)	2.64 (137)	3.27 (162)	2.38 (26)
Site 3	2.18 (244)	2.75 (220)	2.64 (204)	2.33 (235)	3.55 (37)
Site 4	2.17 (1674)	2.51 (1310)	2.30 (1279)	3.23 (2179)	3.88 (888)
Site 5	1.80 (1158)	2.64 (999)	2.57 (394)	3.58 (941)	4.17 (369)
Site 6	1.90 (1048)	2.48 (852)	2.49 (330)	3.76 (720)	4.05 (299)

*No qualitative collections were taken on Feb. 28, May 23, and 30, due to flooding at Site 1.

Pennak (1946) concluded that dissolved oxygen is never a limiting factor in unpolluted streams. Seasonal changes in dissolved oxygen also appear to be unrelated to the periodic fluctuations of fresh water zooplankton (Edmondson, 1946). This conclusion is supported by Eddy (1934) by his observation that the seasonal distribution of plankton seems unrelated, in general, since it is most abundant in summer when dissolved oxygen is the lowest.

Nitrogen nitrate:

The nitrogen nitrate levels never exceeded 39.0 milligrams per liter during this study. Durham and Whitley (1971) and Brummett (1972) reported high values of 44.0 and 71.3 milligrams nitrate per liter, respectively. The data collected by Brummett (1972) show a general decrease in nitrate levels during March and April, followed by a rapid increase during the first week of May. This decline and increase cycle was observed during this study. The application of fertilizers to farm land in the spring was probably responsible for some of this increase. Aldrich et al. (1971) cited fertilizer as the most likely source of increased nitrate in water while urban sewage and livestock wastes also contribute appreciable amounts. The wastes from livestock pastures and feedlots adjacent to Polecat Creek at Sites 1, 3, and 4 may have added more nitrates to the water. It was estimated by Reid et al. (1972) that the livestock population in that part of Illinois drained by the Wabash River contributed untreated waste equivalent to that of 21.7 million persons.

Both this study and the ones done by Durham and Whitley (1971) indicate that the higher levels of nitrate were located at the upstream sites, near the town of Ashmore. Reid et al. (1972) found that all dwellings in Ashmore depend upon septic tanks for sewage disposal. The effluents from the majority of these tanks goes directly to storm sewers or field tiles and eventually into Polecat Creek.

Soluble (ortho-) phosphate:

Chance (1968) reported only one of his 20 phosphate measurements above 1.25 milligrams per liter for the impoundment above Site 6. Brummett (1972) reported only one of 26 phosphate measurements as exceeding 0.4 milligrams per liter. Durham and Whitley (1971) found 8.0 milligrams phosphate per liter at Sites 3 and 4, respectively. These latter data agree with the present study in that the higher levels of phosphate were found near the town of Ashmore. Hammond (1971) cites detergents as accounting for about 50 percent of the phosphate in waste water and for some lower fraction of the total amount entering waterways. Duthie (1972) stated that the undiluted waste water from an individual home has phosphate content which is about two to two and a half times that of municipal wastes. It seems that septic tank drainage at Ashmore is one of the major sources of phosphate entering Polecat Creek and was the probable source of the suds appearing downstream.

Total and calcium hardness:

Both Durham and Whitley (1971) and Brummett (1972) reported total hardness which exceeded 470 milligrams per liter $CaCO_3$ for the lower 7.6 kilometers of Polecat Creek. The total hardness data from this study yielded no reading above 300 milligrams per liter. It appears that the hardness of the water had decreased since 1972. Perhaps the addition of the new housing development at the south end of Ashmore and the subsequent increase in septic tank runoff volume has influenced the decrease in water hardness. Brummett (1972) monitored his lowest total and calcium hardness levels during or following rainfall. While none of the very lowest calcium hardness values were associated with rainfall, there were significant dips in both total and calcium hardness on March 28, May 30, and June 6 which followed heavy rainfall.

It is doubtful that there is any relationship between fluctuations of total and calcium hardness and those of the zooplankton. Pennak (1953) states that most Cladocera occur in water containing a wide range of calcium concentrations.

Hydrogen ion concentration (pH):

There was negligible variation in pH among the sites on any given sampling date. Welch (1952) found that currents tend to keep pH uniform over considerable distances and reduce acidity which accumulates by the addition of free carbon dioxide. Durham and Whitley (1971) collected from the lower 7.6 kilometers of Polecat Creek 12 water samples which averaged .6 above the 7.9 pH average found in this study. Chance (1968) took 17 water samples of the reservoir above Site 6 and found a mean pH value of 7.1. Brummett (1972) reported pH to range from 6.8 to 8.3 for this stream.

Harring and Myers (1928) found that in general alkaline waters contain relatively few species of ploimate rotifers but a large number of individuals, while acid waters contain large numbers of species but few individuals. During this study 26 of the 34 rotifers identified were of the order Ploima with only _Lepadella_ and _Brachionus_ species becoming truely numerous. Pennak (1953) cites _Brachionus_ as an alkaline genus and _Lepadella_ as an acid genus. Contrastingly, Edmondson (1959) described _Lepadella_ as having many species that are likely to be found commonly in hard water. Hutchison (1967) described _Brachionus_ species as almost always found in slightly, if not extremely alkaline waters. No species of _Brachionus_ was recorded by Ahlstrom (1940) in waters more acid than 6.6 pH and in nearly every locality in which its members are conspicuous, the water is alkaline. Eddy (1931) found _Brachionus_ species very scarce in sink hole ponds in southern Illinois which had 6.6 and 6.8 pH values. Hoff (1942) found that most species of Ostracoda do not appear to tolerate waters which are strongly acid.

Stream velocity:

Schmitz (1961, cited by Hynes, 1970) studied the mean current velocity of water required to initiate movement of different bottom deposits. He found that 1.0 to 1.4 meters per second was necessary to move coarse gravel in clear water. No smaller grains than coarse gravel were found at Site 2 which exhibited a mean velocity of .9 meters per second. The mean velocity at Site 3 was .74 meters per second, but the substrate was a mixture of large stones, medium gravel, and coarse sand. Schmitz also determined that medium gravel required .6 to .8 while coarse sand needed only .3 to .5 meters per second velocity of initiate movement. Probably the coarse sand found at Sites 3, 5, and 6 was held in place by the matting effect of algal growths and detritus.

The mean velocity value of .46 meters per second at Site 1 does not show a true picture of the normal current at this location. This discrepancy exists since Site 1 has negligible current when the Embarras River reaches flood stage. Normally this site had a velocity ranging between .5 and .6 meters per second. This rate of flow was quite sufficient in preventing the deposition of silt upon the sand which was continually arriving from upstream.

Pennak (1946) concluded that qualitatively, there are no basic differences between the true plankton of running and standing water, the same taxonomic groups being present in each. However, from a quantitative standpoint, one of the greatest deterents to the development of a plankton population is a strong current. The above "rule-of-thumb" is in compliance with the findings of this study. The main groups of zooplankton could be found at all sites but greater populations were encountered at the more stable, upstream sites. Although most of the data conform to the above generalization, there are several important exceptions which will be discussed later in this section.

Turbidity:

Even though Polecat Creek has the reputation of having very clear water, heavy rainfall can cause turbidity up to an estimated 1750 F.T.U. Chance (1968), Durham and Whitley (1971), and Brummett (1972) reported turbidity highs of 120, 170, and 175 F.T.U., respectively for portions of Polecat Creek with most readings falling below 30 F.T.U. Jackson turbidity units (J.T.U.) approximate Formazin turbidity units (F.T.U.) (Hach, 1973). The relatively slow currents at Sites 4 - 6 allowed much of the acquired particles of turbidity to settle out while the fast currents of the downstream section maintained the suspension of sediment particles until their eventual addition to the waters of the Embarras River. The spates produced by heavy rainfall also appear to dislodge several species of zooplankton off the bottom or from attached growths. The presence of 11 species in the qualitatively collections which occurred exclusively during periods of high turbidity indicate that these organisms may not be entirely free-swimming, but more associated with a substrate in Polecat Creek. It is therefore probable that the following species have some association with a substrate: _Brachionus havanaensis_, _Platyias patulus_, _Ceriodaphnia lacustris_, _Kurzia latissima_, _Moina affinis_, _M. brachiata_, _M. micrura_, Polyphemus pediculus, Ectocyclops phaleratus, Mesocyclops edax, and Orthocyclops modestus. Both Brooks (1959) and Pennak (1953) described C. lacustris as limnetic and Kurzia latissima and Orthocyclops modestus as found among aquatic vegetation. Wilson and Yeatman (1959) found that Mesocyclops edax is also limnetic. Although some of the above species may be described as limnetic in the literature, it is likely that they are also associated with the substrate for feeding.

Air and water temperature:

Hazelwood and Parker (1961) refer to temperature as being the most important single physical factor in determining the population size of the Crustacea portion of the zooplankton. Reid (1961) , Welch (1952), and Edmondson (1946) cite temperature and food as the most obvious limiting factors which could have a physiological effect. By affecting the rates of feeding, reproduction, length of life, and rate of development. Hutchinson (1967) found the rate of egg development in Copepoda to be highly temperature dependent. Most life cycles of calanoid copepods are relatively long, considerably longer than those of planktonic Cladocera. In reference to Cladocera, the effect of increased temperature is to increase the rate at which molts succeed each other and to decrease not merely the instar length but also the length of life.

Van't Hoff's principle (Reid, 1961) holds that the rate at which biological processes proceed is increased nearly two-fold with each 10° C. rise in temperature. As a rule, plankton abundance is greater in summer than in winter, sometimes increasing four-fold or more during a short time in spring. Some species, however, exhibit winter pulses, often producing large numbers underneath ice cover (Reid, 1961).

Summary of environmental parameters:

Reinhard (1931) found that when various chemical parameters, river height, and plankton populations are plotted together, the amounts of inorganic substances vary more closely with the river heights than they do with biological factors. Pennak (1946) emphasized that the quantitative nutrient principle is true only in a general way, but the correlation is not direct and includes many exceptions. Hutchinson (1944) concluded that clear cut correlations between chemical conditions and the qualitative composition of zooplankton are not to be expected. A correlation between two factors may be a manifestation of cause and effect or it may be due to the fact that both factors vary synchronously and proportionally because they are both controlled by a third, extrinsic force (Reinhard, 1931). Generally, the three environmental forces which affected the downstream and seasonal fluctuations of the zooplankton community of Polecat Creek were temperature, velocity, and rainfall.

Zooplankton community:

The only studies done previous to this one which involved zooplankton collections from Polecat Creek were performed by Chance (1968), McCoy (1969), and Durham and Whitley (1971). When reference is made to the above studies it should be kept in mind that they involved the total zooplankton whereas this study was limited to consider only Rotifera, Cladocera, Copepoda, and Ostracoda.

Two studies have been conducted at the large quarry pond upstream from Site 6. Chance (1968) took bi-weekly tows with a No. 12 plankton net, behind a rowboat, between March 7 and May 23. He identified 19 genera and nine species of Rotifera, eight genera and seven species of Cladocera, three genera of Copepoda, and Ostracoda. Four Rotifera (Cuplelagagis sp., Epiphanes senta, Hexarthra mira, Kellicottla longispina) and two Cladocera (Ophryoxus gracilus, Simocephalus serralatus) were found in collections by Chance that were not encountered in this study.

Between July 12 and 13 McCoy (1969) conducted a 48-hour study of the zooplankton of the same quarry pond, also towing a No. 12 plankton net behind a boat. His results yielded the identification of 11 genera and two species of Rotifera, six geners and two species of Cladocera, two genera of Copepoda, and no Ostracoda. One Rotifera (Collotheca sp.) and one Cladocera (Simocephalus sp.) were reported from his collections but were not encountered in this study.

The lists of organisms that Chance and McCoy found were very similar even though their collections were made during different seasons of the year. Their collections show much less variety of organisms than the collections taken for this study. Chance found only two species of Brachionus, whereas this study revealed a total of nine species of this genus. Perhaps their method of taking plankton tows in open water attributed strongly to the smaller variety of zooplankton coming in contact with the plankton net. The methods used for the present study involved many more collections from a wide variety of localities, which were taken nearer the substrate, over a longer period of time, thus yielding a longer list of Crustacea and Rotifera.

As part of a comprehensive, biological study of the streams of Coles County, Durham and Whitley (1971) examined 14 plankton samples from Polecat Creek and found one genus of Rotifera, two genera Copepoda, and the absence of Cladocera and Ostracoda. Because of the comprehensive nature of this previous study, the bulk of the plankton data were reported in number of organisms per liter and not as to composition.

Since the travel time for the water flowing from Site 6 to Site 1 was estimated at less than seven hours, it is unlikely that any of the zooplankton collected in Polecat Creek was produced in the main channel. Eddy (1934) found that in young streams, plankton does not begin to develop until the water is more than a week old. The primary place of zooplankton production was the series of quarry ponds located south of the town of Ashmore. Pool areas and backwaters along the course of the stream may have also provided a stable environment for additional reproduction and development of the zooplankton. These scattered populations would be added to the channel during flooding.

Reinhard (1931) concluded that if all other variables are kept equal, the plankton production of a stream is inversely proportional to its velocity. Kofoid (1908) stated that waters of young streams contain little plankton, but if the same water is impounded for 10 to 30 days, an abundant crop of plankton will be produced. Apparently this is the case in Polecat Creek. The portion of the stream east of Ashmore drains cropland along the 14.5 kilometers of its banks and within a few hours reaches the series of quarry ponds. Here the water spreads out over these shallow impoundments where movement is negligible to nonexistent. The impoundments provide a very stable environment for the production of an abundant zooplankton crop. However, some zooplankton is constantly being lost at the outlets of the quarry ponds, especially when heavy rainfall raises the water level in the stream. Kofoid (1905) and Galsoff (1924) both noted that flood waters tend to dilute the amount of plankton found in waters of large rivers. The effect in Polecat Creek is to wash the organisms from the impoundments and send them downstream. After leaving the impoundments the zooplankton is then subjected to rapids and riffle areas which are common along the remaining 7.2 kilometers of the stream where it experiences a 24-meter drop in elevation. This portion of the stream probably eliminates many of the individuals by the abrasive action and settling effect of turbulent waters. Besides the silting-out effect on Crustacea, Williams (1966) found that silt also always reduces the number of rotifers and observed that they are generally less common in silty rivers than they are in clear ones.

Injury and mortality of plankters may be very high at times of flood (Welch, 1952). In the Mississippi River, Galsoff (1924) noted that 60 percent of the plankton was eliminated by going through the Rock Island Rapids. It was probable that these plankters were destroyed by the collision with suspended sand grains and by inpact against the substrate.

Brachionus and Lepadella were the most characteristic and important Rotifera genera found in Polecat Creek during this study. These genera almost always composed the bulk of the rotifers and sometimes the entire zooplankton fauna. Brachionus urceolaris exhibited a very strong pulse from the beginning of the study to about the middle of March. Kofoid (1908) described B. urceolaris as cosmopolitan in smaller bodies of water. By the end of March, B. calyciflorus was increasing in frequency of occurrence until it reached a plateau in April when it comprised more than 50 percent of the zooplankton. By the first of May, B. calyciflorus had ended its long-term pulse. It was not until May 23 when both Lepadella sp. and B. bidentata began a strong increase of about equal magnitude. The increase in Lepadella sp. was very short-lived (less than two weeks), whereas the pulse of B. bidentata extend until the end of the study. Brachionus quadridentatus exhibited a minor pulse which lasted less than two weeks around May 30. June 13 experienced small increases in B. angularis and B. calyciflorus.

For the entire study period the most common and characteristic members of Cladocera were Alona affinis and Chydorus sphaericus, with the latter species being present in the majority of collections. Pennak (1953) and Brooks (1959) described Chydorus sphaericus as one of the most common of all Cladocera and stated that Alona affinis is usually abundant everywhere in vegetation and littoral zones. Kofoid (1908) described Chydorus sphaericus as a vernal plankter with a well defined pulse in March through June which included 95 percent of the total annual Chydorus population in the Illinois River. Alona affinis was found to appear in the Illinois River in the last part of October, as temperatures approached 5° C. and remain until the end of June, when the summer maximum of 27° C. was re-established. Hynes (1970) observed that crustaceans, which are so important in still-water plankton, are rarely numerous in the open waters of rivers, and those that are found there usually belong to the genera Cyclops, Bosmina, Alona, Chydorus, and Diaptomus. In Polecat Creek both Chydorus sphaericus and Alona affinis appeared to be affected by the trip downstream to a lesser degree than some other cladocerans. The ability of these two species to better withstand the abrasive actions of turbulent water is probably due to their round shape, small body size, and reduction of appendages. The above morphological modifications would also prevent the settling-out of the organisms with the sediment in turbid waters. Rylov (1940, cited by Hynes, 1970) found that cladocerans ingest silt and sand grains which become caught by their complex legs in turbid waters, become heavier, and sink.

In late May and early June, cladocerans such as *Ceriodaphnia reticulata*, *Diaphanosoma brachyurum*, and *Moina brachiata* exhibited an increase which was observable only at the upstream sites (4 - 6). Almost none of these forms ever reached the downstream sites (1 - 3) during this increase. The reason for the absence of these forms at the downstream sites may have been two-fold. It is possible that (1) most were able to actively avoid being washed out of the quarry pond and (2) those that did flow through the outlet were most likely destroyed by the abrasive action of the turbulent waters found downstream.

Rice (1961, 1962) and Fleminger and Clutter (1965) performed laboratory studies which proved that the marine copepod *Calanus*, and certain mysids have the ability to preceive and respond to, changes in hydrostatic pressure. Smyly (1968) found evidence that the fresh water crustaceans, *Daphnia hyalina* and *Cyclops leukarti* could avoid approaching objects by light perception alone. Woltereck (1908), Andre' (1926), Chandler (1939), Brook and Woodward (1956), and Ruttner (1964) found that plankton tend to avoid the outlet areas of lakes. Ruttner (1964) said that the good swimmers, especially the Crustacea, are frequently able to avoid the outlet and so escape being carried out of the lake, perhaps exhibiting a negative rheotropism. Hynes (1970) found that crustaceans can maintain themselves only against flows of up to a few millimeters per second. The very retarded movement of water through the quarry ponds, especially the larger one above Site 6, probably provided ample time for the strong swimmers to reach the quieter waters within the impoundments.

Since *Ceriodaphnia reticulata*, *Diaphanosoma brachyurum*, and *Moina brachiata* were large in size and possessed well developed swimming appendages, they could, im most cases, avoid being swept out of the impoundment by their avoidance response to the current. Those individuals which could not effectively avoid the current of the outlet were eventually eliminated by destruction. Presumably more organisms would be swept out of a reservoir during flooding. Once the strong swimmers have been swept through the outlet, their well developed, spralling appendages immediately become a hazard as they are subjected to the grinding action of the stream below the impoundments. The strong swimmers and other delicate forms are presumably destroyed in a manner similar to which a delicate piece of coral would be reduced in a pounding surf.

The most commonly occurring representatives of Copepoda were nauplius larvae, cyclopoid copepodids, and *Eucyclops agilis*. The almost inevitable presence of nauplius larvae in every collection was just about as predictable as the frequency in which these forms were the dominant copepod representative. Besides being the dominant copepod form of almost every collection, nauplius larvae were frequently the predominant zooplanters, especially at the downstream sites. Probably due to their large numbers, small size, and very reduced appendages, nauplius larvae exhibited the greatest resistance to destruction of any of the zooplankters. This conclusion is in contrast to the findings of Ruttner (1956, cited by Hynes, 1970) who determined that rotifers were more persistent than copepod nauplius larvae during the downstream decrease from a lake. Although to a lesser degree, cyclopoid copepodids and Eucyclops agilis were also resistant to elimation by destruction. All of the above forms experienced their highest frequency occurrence values between late April and early June.

Copepodids and adults from other copepod orders rarely appeared except after a heavy rainfall had churned the bottom sediments and made forms such as the harpacticoid and benthic cyclopoid copepods available to the open waters.

The nauplius larvae were the most commonly encountered Ostracoda form. Although the adult forms are characteristically benthic, their larval stages frequently occurred in open water. Perhaps the small mass of the ostracod nauplius larva, which was very similar to that of the copepod nauplius larva, may have provided the necessary buoyancy for these forms to be a member of the free-floating, plankton community.

On the basis of the morphology of well developed swimming appendages and open water occurrence, the following organisms are probably among the strong swimmers of the zooplankton of Polecat Creek: Ceriodaphnia lacustris, C. megalops, C. reticulata, Daphnia longispina, D. pulex, Diaphanosoma brachyurum, Moina brachiata, Eucyclops agilis, and Diaptomus pallidus. Because Copepoda are better adapted for rapid movement (Szlauer, 1964, 1965, cited by Smyly, 1968), both Eucyclops agilis and Diaptomus pallidus are probably much stronger swimmers than any of the above-mentioned cladocerans.

Possession of a hard covering such as a stiff lorica or carapace would be a logical advantage for an organism to withstand the abrasive action of turbulent water. Apparently a stiff lorica may aid but is not entirely essential in protecting rotifers from abrasion. Buoyancy and the ability to retract delicate structures are probably the major factors which help protect rotifers from the repeated collision with the substrate to which the heavier Crustacea are normally subjected.

The greater abundance of rotifers which exit the impoundment outlets increases the probability that some would survive to be collected at a downstream sampling site. Chandler (1937) concluded that the qualitative decrease of lake plankton entering a stream is related to (1) the volume of the lake plankton entering the stream, (2) water level, and (3) amount of aquatic vegetation at the outlet.

From the collected data it is apparent that the following selected organisms might possess adaptations for withstanding the abrasive actions of turbulent waters: Synchaeta sp., Philodina sp., Chydorus sphaericus, Alona affinis, Bosmina longirostris, copepod nauplius larvae, cyclopoid copepodids, and ostracod nauplius larvae. All other organisms not included in the above list, especially the good swimmers, are probably more susceptible to destruction in the lower portion of Polecat Creek.

One short-coming of reporting the percent frequency occurrence of an organism is the difficulty in monitoring the fluctuations of its associated members of the zooplankton community as the group moves from site to site. The pulse of Lepadella sp. on May 23 serves as a prime example for describing why such scrutiny of the data is important. At Sites 5 and 6 on May 23, Lepadella sp. composed about 20 percent of the community because its competing members (Brachionus bidentata, B. calyciflorus, Euchlanis sp., and copepod nauplius larvae) comprised 47 percent of the total which averaged about 300 organisms for the two sites. When Lepadella sp. was monitored at the Site 4 impoundment, its 3.7 percent value gave no hint of a pulse since the above competing members of the community had increased to 83.0 percent of the 768 organisms counted. When the pulse of Lepadella sp. was monitored on the same date at Sites 2 and 3, the competing members of the community exhibited only a meager one to three percent of the total, leaving a 90 percent value for Lepadella sp. Since very few zooplankters were able to withstand the vigorous trip downstream, those that did survive, even in small numbers, commonly expressed a very high percentage of the much reduced total. Frequently those members of the community that were abundant at the upstream sites were never encountered downstream, thus allowing the few surviving organisms to exhibit exaggerated percentage values at the downstream sites. This phenomenon not only operated for Lepadella sp. but also for Synchaeta, some unidentified nonloricate rotifers, copepod nauplius larvae, and ostracod nauplius larvae.

Combined qualitative data:

The combined qualitative data of Table 12 give further support to the idea that the organisms which can survive the rigorous trip downstream usually show an increase in their percent frequency occurrence. The data show that the two most resistant groups, Copepoda and Ostracoda (mostly composed of nauplius larvae) increased their percent frequency occurrence as they traveled downstream, while the more susceptible Rotifera and Cladocera experienced a decrease. Apparently fewer Rotifera and Cladocera were able to reach the downstream sampling stations than Copepoda and Ostracoda. Also, the much larger numbers of zooplankters encountered at the upstream sites are indicative of the higher productivity and stability of the environment found in the quarry ponds as compared to the running water below the impoundments.

Qualitative vs. quantitative method:

By a comparison of the two collection methods (Table 13) it was determined that the qualitative method underestimated the Rotifera and Copepoda and over-estimated the Cladocera and Ostracoda portions of the zooplankton community when compared to the quantitative method.

The great descrepancy between the number of organisms collected by the two methods should be expected. The quantitative method used in this study involved a measured, 200-liter volume of water, whereas the qualitative method calculated for a 10,000-liter volume to contact a submerged plankton net. Even though the volume calculations for the qualitative method were far from accurate, the submerged net technique was able to collect a greater number of organisms.

It was very evident that the hindrance to water flow caused by the plankton net meshes allowed only a percentage of the water contacting the net to be filtered. Hensen (1895), Kofoid (1903), Welch (1952), Barnes and Tranter (1964), Flemminger and Clutter (1965), Smith et al. (1968), and Likens and Gilbert (1970) discuss an incapacity of a plankton net to accept all the water with which its aperture comes in contact. The filtration efficiency of a plankton net has been found to be influenced by mesh size, age, dryness of the bolting silk, shape of the net, clogging by algae and suspended sediments, velicity of the current, and season of the year. An in-depth analysis of the above influences upon the results of the qualitative method of sampling is, however, beyond the scope of this paper.

It is possible that some adult copepods and cladocerans were able to avoid the net aperture by reacting to the changes in hydrostatic pressure occurring in front of the plankton net. The strong swimmers, which are capable of sensing the approaching net, could actively avoid capture by using the same response they exhibit for avoiding the outlets of lakes. Most of the research on avoidance of zooplankton to an approaching plankton net involves marine organisms but is probably applicable to freshwater situations. Flemminger and Clutter (1965) found that zooplankton may be oriented initially in any direction relative to the trajectory of a sampling device and still disperse away from the path of the device. This avoidance behavior will be increased if the animals are capable of oriented movements. McGowan and Fraundorf (1966) concluded that larger zooplankton are capable of some avoidance, but that the smaller species are not. The use of a bucket in the quantitative sampling probably nullified any avoidance behavior efforts that the stronger swimmers may have exhibited.

Some of the smaller and more buoyant forms such as copepod nauplius larvae and the smaller rotifers may have either been ejected from the net by the backwash-action created at the net aperature, or, to a lesser extent, passed through the larger No. 12 mesh size. Any loss of the smaller zooplankters through the meshes of the No. 12 plankton net was probably very minimal since the mesh size was quickly reduced by clogging from the suspended sediments.

Table 12 indicates that both the qualitative and quantitative method collected about the same number of organisms at Site 1. Possibly the absence of severe clogging of the No. 12 net used in the qualitative method and subsequent loss of the smaller organisms through its meshes may have resulted in the collection of a number of organisms similar to that which was retained by the small-volume, quantitative method, using a smaller mesh (No. 20) plankton net.

Zooplankton populations:

The zooplankton populations in Polecat Creek at Sites 1, 5, and 6 never exceeded 10 organisms per liter (Table 14). In most instances the population exhibited a decrease as it traveled the 210-meter distance from Site 6 to Site 5. The magnitude of this decrease averaged 14 percent, but ranged from two to 73 percent. There were also three instances of a downstream increase between these two sites (April 11, 18, and May 23). Possibly the location of a small quarry pond between Sites 5 and 6 (Fig. 1) may have augmented the population of the stream. However, no data are available to support such a supposition nor was there any coincidence of these increases with any environmental fluctuations, such as rainfall.

The debris, fallen trees, growths of aquatic macrophytes, and frequent riffle areas may have been the causative factors for the downstream population decreases between Sites 6 and 5. Chandler (1937) found 54 and 37 percent decreases of total plankton over a 20-meter section of an unpolluted stream. He determined that the straining efficiency of heavy mats of Lyngbya occurring in this section to be the agent for such dramatic decreases. Upon removal of the mats of Lyngbya, there was no more than a one percent decrease over the same 20-meter distance. Chandler also monitored an 88 percent decrease of total plankton over a .5 kilometer section of a similar stream. Later he determined that log jams, large accumulations of leaves, dead vegetation, and fallen branches were coated with slimy sediments to which many of the open-water plankters seem to adhere. This same .5 kilometer section showed only a 38 percent decrease when this section of the stream contained little debris.

The decrease in population from Site 5 to Site 1 ranged 30 to 88 percent. However, three instances of downstream increases resulted in a downstream increase of seven percent of the mean values (Table 14). The downstream decreases were more common and were probably caused by the elimination of organisms from the lower section of Polecat Creek.

The source of the unusually high population at Site 1 on April 25 was most likely the extensive backwater areas on either side of the banks at this location (Fig. 1). These extensive, shallow areas were separated from the main channel by a few inches of bank height and usually had lush growths of algae over their silty bottom. Although not proven by sampling, such a nutrient-rich environment could produce a massive crop of zooplankton within a short period of time. When the 4.95 centimeter rainfall of April 24 (Fig. 10) raised the water level at Site 1, it also flooded these backwater areas. The inundation of these presummed, plankton-rich backwaters by the relatively barren flood water probably provided the organisms for the local increase on April 25.

The shallow backwaters at Site 1 may have generated a zooplankton community quite different from that which was found in Polecat Creek. On April 25 Philodina sp. was the predominant zooplankter (30.5 percent) in the quantitative sample from Site 1. It would seem logical to also find Philodina sp. as the predominant form in the qualitative collection for Site 1, since the two methods were performed almost simutaneously. However, the qualitative sample for Site 1 on April 25 showed Philodina sp. comprising only 1.9 percent and Brachionus calyciflorus as the predominant form (43.4 percent). B. calyciflorus was the predominant zooplankter for all other collections made on that date. A possible explanation for the almost absence of Philodina sp. in the qualitative sample may be the inability of the wider meshes of the No. 12 net to retain such soft-bodied forms as Philodina sp. Likens and Gilbert (1970) found that another soft-bodied rotifer, Polyarthra, appeared to squeeze through the small apertures of a plankton net more readily than hard-bodied forms such as Keratella. The net used for the qualitative method was a No. 12 and the one used for the quantitative technique was a No. 20 *Philodina* sp. may have been able to sqeeze through the larger meshes of the No. 12 net but retained by the smaller mesh, No. 20 net.

There appears to be a slight coincidence of high turbidity and the population increases to over 100 organisms per liter. This association could possibly be due to the addition of benthic and periphyton plankters by increases in water velocity.

Species variety:

On the basis of the number of species occurring in a given collection (Table 15) and the number of organisms collected (Table 12) it may be concluded that the upstream portion of Polecat Creek (Sites 4 - 6) are more stable and productive than those found downstream.

The smaller volume used for the quantitative method was responsible for encountering fewer species than the large-volume, qualitative method. As mentioned previously, turbidity did not seem to greatly influence increases in population. However, there appears to be more evidence to support the idea that turbidity increases the number of species encountered in a collection by scraping benthic forms off the substrate and attached growths and making them available to the open waters.

Species diversity indices:

Diversity is often defined as simply the number of species occurring in a collection. Such a definition does not take into account the relative abundance of each species. Clearly some measure is needed to incorporate information about the relative abundance of species when comparing the diversity of two or more communities. The above requirement redefines species diversity as the importance of number and relative abundance of species in the taxon or trophic level under consideration in community comparisons (Uetz, 1974). Several methods for mathematically expressing the species diversity of a community have been developed within the last 30 years. Although there are now about 30 species diversity measures (Uetz, 1974), the Margalef, (1968) information equation ($D= -\sum p_1 \log_2 p_1$) was found suitable for this study.

Diversity is a measure of predictability. Species diversity is high when it is difficult to predict the exact species of an organism randomly chosen from the community, and low when it is not. The greater the number of categories (species) and the more nearly equal their numbers, the less is the predictability, and the greater is the diversity (Pielou, 1966). If there is only one species in a community, for example, the uncertainty of a random sample containing this organism is zero. Likewise, the diversity value will also equal zero, because the relative abundance of the single organism = 1.0 and $1.0 \log_2 = 0$. For any given number of species, diversity will be greater if the species are equally abundant (Wilson and Bossert, 1971).

The plankton collections yielded 71 zooplankton taxa (Table 2) for Polecat Creek and resulted in monthly, species diversity values which ranged from 1.30 to 4.17 (Table 16). During a 12-month study of Keystone Reservoir, Oklahoma, Koschsiek et al. (1971) collected a total of 44 taxa of zooplankton. More than half (26) of his list of 44 taxa were found in Polecat Creek. He also computed species diversity indicies using the identical information equation by Margalef (1968) and found values ranging from 1.19 to 3.43. Since the upstream portion of Polecat Creek showed the highest upper range of diversity values it may indicate an older or more mature community than that found in the larger Keystone Reservoir which exhibited the lower values.

The smooth diversity increases from one month to the next at Sites 4 - 6 may have been influenced by the stable habitat of the upstream sampling stations. Pianka (1974) described three ways in which communities may increase their species diversity: (1) greater range or amount of resources (more niches), (2) each species may exploit a smaller fraction of resources (smaller niches), or (3) existence of a greater degree of niche overlap between species (sharing of resources). It is very probable that the nutrient-enriched habitat and idle waters of Sites 4 - 6 provided ample niches and resources for the production of an increased diversity. In general, more links in a food web (MacArthur, 1955), more cases of parasitism, symbiosis, etc. (Margalef, 1968) promote greater stability of a system. Increased stability, which is usually correlated with an increased number of species, increases diversity.

It may appear a bit strange that the slowly flowing water of Sites 5 and 6 exhibited a greater diversity than the stable habitat of the Site 4 impoundment. Competition among zooplankton species in the Site 4 impoundment seems to be responsible for making the relative abundance of each species less nearly equal, thus yielding a lower species diversity value. A prime illustration of this type of competition can be found in the case of Lepadella sp. and its competing constituents on May 23, which was previously discussed on page 102. Competition acts to decrease diversity by causing unequal populations of several species in a community. Restrictions by one species on another (differential growth rate, reproductive pulses, crowding, etc.) shift the populations of the community from the state of nearly equal abundance, and consequently reduce diversity (Roth, 1967). Another possible source of the diversity depression experienced at Site 4 was the location of a crowded cattle pasture adjacent to its banks. In addition to the normal runoff from this well-used cattle pasture, animals could freely enter the impoundment or stream to excrete directly into the water. Prather and Prophet (1969) determined that a decrease in species diversity can be caused by runoff from commercial feed lots. Similarly, Wilhm and Dorris (1968) found that organic pollution results in a depression in diversity of benthic macroinvertebrates.

The irregular, monthly fluctuations of species diversity values for Sites 1 - 3 were most likely due to the selective nature and instability of the turbulent water present in the downstream portion of Polecat Creek. There is also a possibility that these downstream values may be overrated since there were very few organisms encountered in the collections from these stations. Margalef (1968) suggested that the species diversity of plankton in turbulent water may be excessive in small samples due to the continued destruction of their spatial distribution by the churning water. However, such an overrated species diversity curve soon flattens and remains nearly constant as the sample sizes increase.

The most obvious change in species diversity of the Polecat Creek community was its coinciding increase with the succession of seasons. Uetz (1974) noted that one major trend which has been repeatly observed is that communities tend to diversify in time as ecological succession occurrs. Early successional stages have lower species diversity, and later stages have increased species diversity. Margalef (1963) found this rule to operate in microcosm pond water succession in the laboratory, while numerous field studies have confirmed this observation. During a seasonal succession, species diversity usually increases very rapidly through an "overshoot" and then decreases before leveling off in a fairly stable pattern before declining (Roth, 1967). Population densities often show this trend, especially in secondary succession on upland areas (Odum, 1959). Kochsiek et al. (1971) found that the zooplankton deversity in the

Keystone Reservoir, Oklahoma decreased slightly through early winter and decreased abruptly and reached minimum values in late winter and early spring, after which they increased to the initial values. Evidently this study had begun during the late winter minimum and ended when the diversity was exhibiting its annual, rapid increase.

Some physiochemical conditions have shown correlation to the changes in species diversity values. Kochsiek et al. (1971) found that the inverse relationship between temperature and dissolved oxygen resulted in a negative correlation between diversity and oxygen and a positive correlation between diversity and temperature.

Probable changes in the zooplankton community by the construction of a reservoir:

The major limiting factor in plankton production in Polecat Creek is the presence of a current. Even though the series of quarry ponds is the main source of plankton production, periods of inundation always alter the water level and flow within these impoundments. While monitoring the fifteen-month filling of Devil's Kitchen Lake, Illinois, Field (1960) reported that major fluctuations in water level caused plankton populations to decrease or disappear by preventing the establishment of stable conditions. The disturbing feature of current can be elimated the creation of a reservoir which would provide the environmental stability needed for growth of a mature zooplankton community.

Upon filling of a reservoir, the response of bacteria and phytoplankton would be almost immediate (Ackermann et al., 1973). After the dam across the Sangamon River was constructed in 1922, the plankton of the newly formed Lake Decatur began to show a steady progression towards a stable community. Each year a few additional species appeared but no species actually desappeared (Eddy, 1934). During such a progressive maturation of the plankton community, the phytoplankton component usually develops before that of the zooplankton. Since the impounded waters of Polecat Creek already possess well-developed, plankton communities, their eventual availability to a downstream reservoir would probably accelerate the maturation process of the zooplankton.

The damming of Polecat Creek would create a much deeper reservoir than any of the impoundments near Ashmore, and stratification of the water would result. Consequently, the newly formed hypolimnion would provide niches to the zooplankton which were previously not available. The list of species found in Polecat Creek would be duplicated, but the open niches in the deeper water might allow for increased variety. Because of its increased depth and area, there would be an increase in productivity of such a reservoir (Ackermann et al., 1973).

In general, reservoirs delay river temperature rise in the spring and decline in the autumn, since more time is required for their great volumes of water to approach air temperatures (Neel, 1963). Due to the slower rising temperatures in a deep reservoir, the periodic pulses of the zooplankters would most likely be delayed and more gradual than the sometimes dramatic increases as found in Polecat Creek.

The most obvious reservoir effect on turbidity is the near-complete removal of carried-in silt and suspended materials (Neel, 1963). The location of the series of quarry ponds upstream would help in the reduction of the silt load of very turbid water prior to its arrival at a downstream reservoir. However, continued soil erosion and nutrient enrichment from fertilizers, domestic sewage, and animal wastes will eventually fill-in these ponds and eliminate their function as a "silt dump" for water-borne sediments. Dendy et al. (1973) studied 1105 small reservoirs (less than 100 acre-feet) in the United States and found a 54 percent loss of storage capacity in 20 years. Such a decrease in depth and associated increase in nutrients would eventually render the zooplankton community of a newly constructed reservoir similar to that of the Site 4 impoundment within a few decades. Sound recommendations for increasing the longevity of a future reservoir on Polecat Creek would be the installation of a sewage treatment facility for the town of Ashmore and the control of runoff within the watershed, prior to construction.

VIII. CONCLUSIONS

1. A total of 142, replicate, plankton collections yielded 71 zooplankton taxa, representing Rotifera, Cladocera, Cope-

poda, and Ostracoda for the lower 7.6 kilometers of Polecat Creek.

2. Temperature, rainfall, and current velocity influenced the fluctuations exhibited by the zooplankton.

3. The seasonal succession of temperatures was directly related to increases in the number of zooplankton taxa encountered and to increases in species diversity indices.

4. Rainfall was directly related to increases in turbidity which was found to be responsible for a few of the population increases and many of the increases in the taxa occurring in a given collection. The washing of benthic zooplankters from their substrate habitat, during times of high water, is believed responsible for making them available to the open water for subsequent collection. Also, increased water levels occassionally carried some zooplankters further downstream.

5. Increases in current velocity usually exhibited a negative influence upon zooplankton productivity and also caused the elimination of many forms, probably by destruction. The negligible current found in the Site 4 impoundment was most likely related to its longer list of taxa.

6. The major, downstream decreases are believed to have been caused by (1) destructive elimination by the abrasive effects of turbulent waters, (2) successful avoidance of the impoundment outlets by strong-swimming zooplankters due to their reactions to changes in hydrostatic pressure, and (3) removal

by debris, attached algae, and aquatic macrophytes.

7. The other environmental parameters (D.O., NO_3, PO_4, total and Ca^{++} hardness, and pH) were found to be unrelated to the fluctuations of the zooplankton.

8. The primary site of zooplankton production was the series of quarry ponds south of the town of Ashmore. Secondary sites of production were the quiet pool areas along the main channel. The shallow, backwater areas adjacent to Site 1 are suspected as an important zooplankton addition to the almost barren waters of the main channel during times of flooding. It is unlikely that any zooplankton production occurred in the main channel.

9. Rotifers exhibited the most pronounced periodicity pulses of any group. The following is a listing of the more important species and the duration of their pulses: *Brachionus urceolaris*, February 21 - middle of March; *B. calyciflorus*, middle of March - first of May, June 13 - ?; *Lepadella* sp., May 23 - May 30; *B. bidentata*, May 23 - June 13+; *B. quadridentatus*, May 30 - June 13+; *B. angularis*, June 13 - ?.

10. *Alona affinis* and *Chydorus sphaericus* were the most common and characteristic Cladocera, both species appearing to be less affected by the abrasive action of turbulent waters. *Ceriodaphnia reticulata*, *Diaphanosoma brachyurum* and *Moina brachiata* exhibited an increase between late May and early June.

11. The most commonly occurring representatives of Copepoda were nauplius larvae, cyclopoid copepodids, and Eucyclops agilis, which also were able to survive turbulent water better than some other forms. Copepod nauplius larvae were the most commonly occurring zooplankter throughout the entire study. All of the above forms exhibited their highest frequency occurrence between April and June.

12. The nauplius larva was the most commonly encountered Ostracoda form.

13. The difference in the mesh between the two plankton nets was probably not very significant when sampling mildly turbid waters since the aperture size of the No. 12 net was usually, greatly reduced by clogging.

14. The greater volume involved in the qualitative method resulted in the collecting of many more zooplankters than by means of the quantitative method.

15. The qualitative method caused slight underestimation of the Rotifera and Copepoda and a slight overestimation of the Cladocera and Ostracoda portions of the zooplankton community when compared to the quantitative method. It is felt that the bias between the two methods does not impair the basic conclusions of this study.

16. Qualitatively, Copepoda and Ostracoda increased while Rotifera and Cladocera decreased in relative frequency occurrence as the zooplankton traveled downstream.

17. The zooplankton populations at Sites 1, 5, and 6 never exceeded 10 organisms per liter and commonly, with a few exceptions, exhibited downstream decreases.

18. The stability of the upstream sampling sites, especially the Site 4 impoundment, allowed for interspecies competition which frequently resulted in a much different community composition than found at the downstream sampling stations. At times, those members of the community that competed for percentage points at the upstream sites overshadowed the pulses of other members, but were eliminated prior to their arrival at the downstream sites. The organisms which did survive the rigorous downstream journey usually exhibited exaggerated percentage values relative to their upstream expression. The fewer number of organisms encountered at the downstream sites also may have contributed to the increased nature of their percentage values. This phenomenon operated for Lepadella sp., Synchaeta sp., some unidentified nonloricate rotifers, copepod nauplius larvae, and ostracod nauplius larvae.

19. Sites 4 - 6 experienced a much smoother, seasonal progression of species diversity index values than Sites 1 - 3, which were very erratic. Due to interspecies competition and nutrient enrichment, Site 4 exhibited a considerably lower species diversity index value than the slowly moving waters of either Site 5 or 6.

20. The deep-water reservoir created by the damming of Polecat Creek would probably experience a relatively accelerated

maturation rate of its zooplankton community due to the already well-developed communities in the upstream quarry ponds. The resulting species list that would eventually appear in such a reservoir would include more species than now found in Polecat Creek due to the additional niches contained in the deeper water. The characteristic reservoir delay in the temperature rise in spring and decline in autumn may cause the cyclic pulses of the zooplankters to be more delayed, less pronounced, and more prolonged than those now exhibited in the stream. It is suspected that if the town of Ashmore does not install a sewage treatment facility and surface runoff within the watershed is left unchecked, the capacity of such a reservoir would be drastically reduced within a few decades. Such a change in the reservoir morphology would revert the zooplankton community back to what is now characteristic at the Site 4 impoundment.

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APPENDIX

IV. FIELD METHODS AND PROCEDURES

A. Biological sampling of stream sites:

Prior to the commencement of the sampling program, several collection techniques were evaluated for the study of the Rotifera, Cladocera, Copepoda, and Ostracoda of Polecat Creek. Reconnaissance sampling by means of pouring 500 liters of water through a No. 12 plankton net yielded an insufficient number organisms to provide a valid picture of the zooplankton community of Polecat Creek. Neither an adequate pump nor a metered-net could be obtained, nor was it physically possible to actively pour sufficient water through a net. A passive-type of collection was chosen because of the abovementioned limitations.

Plankton samples were obtained by permitting the water to flow through a plankton net which was suspended, in a fixed position, in the middle of the stream. A sufficient number of organisms could usually be collected with this technique by extending the time duration for which the plankton net was exposed to the stream current. The net used was a nylon, No. 12, standard plankton net with 116 micron mesh size. This net had an inside aperture of 15 centimeters, a length of 40.6 centimeters, and a chain leader attachment for towing. The distal end of the plankton net was fitted with an aluminum, screw-type, adapter for the attachment and removal of a 34 milliliter collection vial.

A wooden tripod with legs measuring 177 centimeters in length was used to suspend the plankton net in the middle of the stream. This tripod was placed on the stream bed with two legs perpendicular to the oncoming current and the third leg positioned in a downstream direction. The two legs which faced upstream were then connected by a small cord. The point of attachment of this cord on each tripod leg was one to two centimeters above the water. For the collection of a plankton sample the plankton net was afixed to the center of this connecting cord by its chain leader attachment. This arrangement allowed the water of the stream to pass through the suspended plankton net while being only slightly affected by the eddies and turbulence produced by the tripod structure. The "drag effect" of the stream flow was usually sufficient to draw the plankton net into a position which was approximately parallel to that of the current. However, when the stream velocity was slow, the plankton net tended to hang in an oblique angle to the flow of the current due to the insufficient "drag effect" of the slower moving water. By connecting the collection vial to the rear leg of the tripod, the plankton net could always be maintained parallel to the flow of the water regardless of its velocity. Due to fast current, it was sometimes necessary to weight the tripod by tying a large rock to the point where the legs were fastened together.

During sampling the plankton net was maintained at a depth between two to five centimeters from the surface. From one sampling date to the next the tripod was returned to the same, marked position on the stream bed at each respective site. The only deviations from this plan of consistency occurred during periods of unusually high water. At such times the plankton net was attached to a tree limb or some similar structure by a length of rope. This alternate method adequately approximated the tripod method in effect. Collections were made weekly, during daylight hours, for 17 weeks, beginning on 21 February, 1975, and ending on 13 June, 1975. The weekly sampling began at Site 1 and ended with Site 6.

Upon arrival at each site, except Site 4, collections of plankton samples were accomplished by the following steps:

1. Flow rate determination:

At the beginning of the study, flow rate was determined by timing the movement of a float over a measured distance. The float was a plastic, one-liter volume, sample bottle which was filled with approximately 950 milliliters of water. The mean value of five timings of this float over a 20-meter distance was used to calculate stream velocity as expressed in meters per second. A 10-meter, measuring distance was substituted at Sites 5 and 6, since these portions of the stream possessed a less than 20-meter distance in which the stream bed was relatively straight and the flow rate uniform.

On 14 March, 1975, this float method of stream velocity determination was replaced by a current meter (Pygmy type; F583- Nov. 1974; Weather Measure Corporation: Sacramento, Calif.). This instrument was considerably more accurate than the float method and could determine flow rate a one point in the stream. Four tests, each of one minute duration, were taken to determine stream velocity at each sampling site. Two of these tests were taken at approximately two centimeters below the surface of the water and another two were taken at a depth of about 15 centimeters. The mean value obtained by these four test was then used to calculate flow rate as expressed in meters per second.

A total of nine comparison tests were conducted to determine the degree and tendency of error produced by the float method over the metered method. The averaged results are given below:

Site No.	No. of comparison tests/site	Tendency of error	Percentage error (%)
1	1	Overest.	10.81
2	3	Overest.	12.03
3	2	Overest.	8.67
5	1	Overest.	10.81
6	2	Overest.	2.34

An overestimation of the flow rate by about 10 percent appears to be the error produced by the float method if the current-meter is considered as accurate. Either method of flow rate determination was considered valid for the purposes of this study since a high number of organisms was usually collected by either method and the total count of organisms was used to determine only the percentage composition and not the population itself.

2. Determination of the volume of water to come in contact with the plankton net aperture.

By knowing the flow rate of the stream at the site of sampling, it was possible to calculate the duration of time necessary for a volumetric column of water, 15 centimeters in diameter to come into contact with the plankton net aperture. A 10,000 liter volume was calculated by the formula

$$t = \frac{10,000}{(\pi r^2)f}$$

where "t" is the time (in seconds) necessary for 10,000 liters of water to come into contact with the plankton net aperture, "r" is the radius (in centimeters) of the plankton net aperture, and "f" is the flow rate (in meters per second). Certainly not all of the water which came into contact with the plankton net went through the meshes. The volume which was filtered varied inversely with the flow rate. This method satisfied the purposes of this study since an adequate number of organisms and not a specific volume was required for a valid determination of the zooplankton community and its percentage composition. This method of volume calculation also provides a means of duplicating the sampling methods used in this study.

3. <u>Exposure of the plankton net to the current</u>:

The plankton net was exposed to the water current for the amount of time required for a column of water, approximately 10,000 liters in volume, to come into contact with the aperture of the net. At the beginning of the sampling period, the plankton net was attached to the tripod apparatus and then removed at the termination of the sampling period. By means of a clock and the ease by which the net could be attached to and removed from the tripod stand, it was a relatively simple matter to accurately time the sampling period within a few seconds. For convenience, the volume was calculated from a timed period which was terminated at half minute intervals. Two replicate samples were taken at each sampling site.

4. <u>Washing of the plankton net and preservation of sample</u>:

After the net had been carefully removed from the tripod stand, the sides of the net were washed down by repeatedly lowering the net into the water up to the aperture collar and then lifting to permit drainage. The collection vial was first placed in an open, 140 or 230 milliliter sample jar and then removed from the plankton net adapter. Next, the contents of the collection vial were placed into the labeled, sample jar and the vial re-attached to the end of the plankton net. Then, the washing, draining, and transfer of vial contents was repeated as above. Thus, the plankton net was washed down twice and the contents of each washing placed into a labeled, sample jar. Concentrated formalin was immediately added to the sample concentrate until a five to ten percent solution had been attained.

B. Biological sampling of Site 4:

Site 4 was represented by a small quarry pond through which Polecat Creek flowed. A 98-meter, east-west transit line was surveyed across the longest dimension of this pond with the end points designated by marker flags located on the banks. Both end points of the transit line were about five meters from the shores where the water was about two meters deep. Sampling was accomplished by towing the same No. 12 plankton net at about a five-meter distance behind a rowboat. The speed of rowing was adjusted so that the net was maintained in the upper one-meter of surface water. In order to approximate the 10,000 liters of water coming into contact with the aperture of the plankton net, six trips between the end points of the transsit line were made for each of the two replicate samples. Since the plankton net was never washed down while sampling was in progress at any other site, the boat was not halted upon arrival at the end points of the transit line. Rather, the boat was turned around near the ends of the transit line while maintaining the depth of the net in the upper, one-meter of surface water. Washing of the plankton net, transfer of the collection vial contents, and preservation of the sample concentrate were as described previously.

C. Quantitative sampling of Sites 1, 5, and 6:

In late March, 1975, a No. 20, nylon plankton net with a 80 micron mesh size was ocquired for use in this study. Beginning on April 4, 1975, 200 liters of water were poured by bucket through this No. 20 plankton net at Sites 1, 5, and 6. The net was suspended from a tree branch to facilitate the pouring operation. The approximate, top 30 centimeters of surface water were sampled by repeated filling of a measuring bucket with 10 liters of water. After the 200-liter volume had been poured into the net, stream water was splashed on the outside surface of the net to wash down all visible silt and debris into the collection vial. The procedures for transfer of collection vial contents and preservation of the sample concentrate were as described previously.

D. Field analysis of chemical and physical parameters:

Air temperature, water temperature ($C.^{o}$) and dissolved oxygen measurement (mg. / l. O_2) were taken on every visit to each sampling site by an exygen meter (Model 54 - Yellow Springs Instrument Co., Inc.). The oxygen meter was calibrated to barometric measurements from the Coles County Airport and air temperatures at each sampling site prior to the measurement of dissolved oxygen. After the above calibration, the sensing probe was submerged in the current of the stream. A period of at least one minute was allowed for the instrument to stabilize prior to reading the instrument. The water temperature was taken immediately thereafter. Site 4 was sampled in the same fashion while the boat was anchored in the approximate center of the pond. Casual observations were made of the floating debris, description of stream bed, and emergent vegetation on every visit to each site.

E. Field collection of water for laboratory analysis:

Water samples were obtained by completely submerging a closed, 300 milliliter sample bottle, followed by the removal of its glass stopper. The stopper was replaced when the bottle had become completely filled. After sampling operations were completed at a sampling site the sample bottle was placed in a ice-filled cooler for transportation back to the laboratory for analysis.

V. LABORATORY METHODS AND PROCEDURES

A. Water analysis:

Water samples taken in the field were analyzed for nitrogen nitrate, soluble orth-phosphate, calcium hardness, total, hardness, turbidity, and hydrogen ion concentration as follows:

Nitrogen, nitrate (mg. / l. NO_3-N:

Reduction method - NitraVer V. for water and wastewater. Hach DR/2 Spectophotometer. Water analysis, 1973; Hach Chemical Co., Ames, Iowa.

Soluble (ortho-) phosphate (mg. / l. P):

Ascorbic acid method - PhosVer III. for water and wastewater. Hach DR/2 Spectophotometer. Water analysis, 1973. Hach Chemical Co., Ames, Iowa.

Calcium hardness (mg. / l. $CaCO_3$):

Titration method - CalVer II. for water and wastewater. Hach DR/2 Spectophotometer. Water analysis, 1973. Hach Chemical Co., Ames, Iowa.

Total hardness (mg. / l. $CaCO_3$):

Titration method - ManVer II. for water and wastewater. Hach DR/2 Spectophotometer. Water analysis, 1973. Hach Chemical Co., Ames, Iowa.

Turbidity (Formazin turbidity units - F.T.U.):

Absorptometric method for water. Hach DR/2 Spectophotometer. Water analysis, 1973. Hach Chemical Co., Ames, Iowa.

Hydrogen ion concentration (pH):

Fisher Accumet pH meter, Fisher Scientific Co., St. Louis, Mo.

The determination of nitrogen nitrate, ortho-phosphate, calcium hardness, and total hardness were performed twice and the values averaged. Values for the measurement of turbidity and hydrogen ion concentration were performed once.

B. Plankton analysis:

Each replicate sample was analyzed by the microscopic examination of three Sedgwick-Rafter survey counts. A large capacity (2.5 milliliters) eyedropper was used to withdraw aliquots from the sample jars. The bore-end of the eye dropper was enlarged to an inside diameter of three millimeters. In preparation for the withdrawal of an aliquot, the sample jar was stirred vigorously with the eyedropper until all material was suspended. The stirring was then halted for exactly three seconds. Immediately thereafter, the aliquot was withdrawn. The withdrawal was done by placing the eyedropper, with the bulb depressed, against the inside wall of the sample jar about midway between the surface and the bottom. The bulb of the eyedropper was released as its end moved horizontally across the inside of the sample jar. The above technique withdrew approximatedly one milliliter of liquid and took about one second to perform. The contents of the eyedropper were quickly dispenses at the corner of the Sedgwick-Rafter cell with the cover slip placed diagonally across the chamber. Finally, the coverslip was moved into place, thus sealing the counting chamber.

The purpose of the above-mentioned, three-second wait was to allow the very largest sand grains to settle to the bottom prior to withdrawal of the aliquot. This technique was important for samples taken at Sites 1, 2, and 3, where the sediment content within the sample jar, sometimes, exceeded one centimeter in depth. When such sediment-filled samples were suspended and aliquoted without a three-second wait, the Sedgwick-Rafter cell became opaque with sand grains. The three-second delay technique prevented much of the coarse sand from entering the counting chamber. Little to no decrease in the circulation rate of the stirred sample was noted during this three-second wait.

Counting and identification were done at 100x (10x oculars and a 10x objective) with occassional switching to 15x oculars and use of the 2x zoom adjustment for resolution of taxonomic detail. The numeric values found in the results section are derived from the summation of the six survey counts for the two replicate samples from each respective site.

In most cases, organisms were indentified to species. Rotifers provided the most difficulty since an adequate preservation method was not found for the weakly loricate forms. Most Cladocera and adult Copepoda were identified to species except when some diagnostic character was obscured from sight by debris or the organism itself. Ostracoda were not identified below the subclass taxon since the necessary procedures were impossible under the cover slip of the Sedgwick-Rafter cell. Identification was done with the aid of the following taxonomic references: Ahlstrom (1940, 1943), Brooks (1959), Chengalath et al. (1971), Coker (1934), Eddy and Hodson (1961), Edmondson (1959), E. B. Forbes (1897), Marsh (1910), Needham and Needham (1962), Nipkow (1952), Pennak (1953), Schacht

(1897), Torke (1974), Wilson and Yeatman (1959), and Yeatman (1944).

X. REVIEW OF THE LITERATURE

<u>Beginnings of zooplankton study</u>:

The development of magnifying lenses by the Assyrians, Arabs, Romans, and various Europeans between the second and fifteenth centuries and the invention of the compound microscope by Zacharias Janssens in 1590 (Gardner, 1965), provided the necessary equipment for systematic plankton investigations. Anton van Leeuwenhoek (1632 - 1723) was the first microscopist to describe the minute organisms found in water (Welch, 1952). Swammerdam (1685, cited by Slobodkin, 1954) observed a seasonal maxima of a population of Cladocera.

About 1845, Johannes Müller was probably the first to use very fine mesh nets for the collection of plankton (Welch, 1952). Near the time when Charles Darwin published <u>The Origin of the Species</u>, (1859), two Norweign investigators, Liljeborg and Sars described the composition of the plankton. They found a flora and fauna, mostly microscopic representing most of the food trophic levels (Needham and Lloyd, 1916). In 1887, Hensen proposed the term "plankton" to include all the minute animals, plants, and debris which are suspended in natural waters (Welch, 1952). Zacharias (1898, cited by Kofoid, 1908) described the plankton of rivers as "potamoplankton." Phytoplankton was classified by Griffith (1923) in terms of the ecological nature prevalent in the habitat.

Thus, plankton found in moving water, such as a stream or river is termed "rheoplankton" and that found in ponds and lakes is denoted as "limnoplankton."

Biological investigations in Illinois involving planktonic Crustacea and Rotifera:

Stephen A. Forbes, the first chief of the Illinois Natural History Survey, began one of first zoological studies of the Illinois river system in 1874. By 1928, the Survey had published 20 bulletins on the biology of Illinois rivers (Forbes, 1928). A list of Illinois Crustacea with descriptions of new species (Forbes, 1876) was the initial bulletin published by the Illinois Natural History Survey then known as the Illinois State Laboratory of Natural History. Later, Forbes (1878, 1883a, 1883b, and 1888) conducted food studies of fishes, identifying the Crustacea eaten by the young. Forbes (1882) gave a systematic description of a few rare copepods from Lake Michigan and adjacent waters including eight new species. E. B. Forbes (1897) completed another, similar work on the Cyclopidae of North America.

Sharpe (1897) studied the North American Ostracoda and described food ralationships, ecological associations, seasonal occurrences, and provided a key to the genera which included 10 new species. This study represents the first work done on the Ostracoda of Illinois.

Methods and apparatus used by the biological station of the University of Illinois for plankton investigations was described by Kofoid (1897). A description of the taxonomy of the North American species of Diaptomus by Schacht (1897), included some discussion of habitat and complete illustrations of species. Hempel (1899) studied the Protozoa and Rotifera of the Illinois River and adjacent lakes at Havana, which included seasonal and geographic distribution, food relationships, with ecological and taxonomic descriptions of each species encountered.

From an exhaustive study of the plankton of the Illinois River, 1894-1899, involving 645 collections from seven localities, Kofoid published three articles. Kofoid (1903) discussed the errors produced in quantitative plankton studies by variations in the age, filtration effeciency, and clogging of the plankton net used, and presented a method to caculate a "coefficient factor" as a corrective measure for such bias. Also provided in this paper and his next major work (Kofoid, 1908) is the presentation of the quantitative plankton analysis for the Illinois River, 1897 - 1899, including detailed, enumerated conclusions about the basic characteristics of the plankton ecology, trophic relationships, seasonal pulses, reproductive cycles, and descriptions of each individual species encountered and their type-variations. In a very short paper, Kofoid (1905) discussed the effect of flood water, drought, current, tributaries, and temperature upon the plankton of the Illinois River and stresses its importance as an element in the food chain of fishes.

The total plankton (phytoplankton and zooplankton) from Lake Michigan collections made between 1887 - 1888 and 1926 - 1927, were analyzed and discussed by Eddy (1927) which provided specific notes on each constituent organism. Shortly thereafter, Eddy (1931) studied plankton samples from sink hole ponds in Pulaski County, Illinois. Three ponds were choosen which represented progressive stages of ecological succession. All three ponds contained abundant plankton which was similar in some respects to that of rivers and other ponds except for the abundance of several characteristic species such as <u>Trichocera</u> <u>multicrinis</u>, and the absence or scarsity of <u>Brachionus</u> species. Later, the plankton of the Sangamon River was investigated by Eddy (1932). Most of the discussion of this paper was devoted to the effects of the dam creating Lake Decatur and the sewage treatment plant effluent entering the Sangamon River downstream from the reservoir.

Eddy (1934), in his most important work, involving over 2,000 collections of plankton from lakes, streams, and ponds (mostly in the United States) described and defined the characteristics of fresh-water plankton communities and their interrelated dynamics. A number of major Illinois streams were investigated which included the Illinois, Fox, Rock, Wabash, and Sangamon rivers. Also, a number of minor streams were examined including the Green River near Geneseo, Deer Creek, Elkhorn Creek in Whiteside County, Pecatonica River at Pecatonica and Harrison, Kishwaukee River at Rockford, Leaf River near Byron, Stevens Creek near Decatur, and the Salt Fork at Oakwood. Eddy described how the plankton element of fresh-water communities can be compared to that of the organisms of terrestrial communities in respect to behavior and development. Terms such as predominant, prevalent, socies, hiemal, vernal, serotinal, estival, and climax community were defined and explained with illustrative examples.

A very valuable and complete bibliography of the ecology of Illinois, by Vestal (1934) provides citations for papers published in the late 1800's and early 1900's, many of which are not indexed in Biological Abstracts or The Zoological Record.

The taxonomic investigation of North American fresh-water Ostracoda by Sharpe (1897) represented the only major systematic work done on Ostracoda of Illinois until Hoff (1942) did his extensive qualitative study of 713 field collections from 66 counties in the state. Included in this study is a rather complete review of the literature on Ostracoda (European and North American), details of ecological associations, and a systematic description of each species with complete illustrations. Hoff (1943) published a short paper on the seasonal changes of the Ostracoda fauna in tempory ponds.

The following are three master's theses involving zooplankton studies in Illinois. Parmantie (1959) did a qualitative study of the plankton population of Sportsmen's Lake, Bloomington, Illinois. Field (1960) monitored fluctuations in plankton populations during the filling of Devil's Kitchen Lake. Applegate (1961) compared the effects of fertilization upon net plankton of three southern Illinois ponds.

In a comprehensive limnological study of the floodplain pools in the Kaskaskia River basin, Larimore et al. (1973) provided only cursory treatment of the role of zooplankton as food for fishes and macroinvertebrates.

Biological investigations in Coles County, Illinois, involving planktonic Crustacea and Rotifera:

One of the first zooplankton studies done in Coles County, Illinois, was performed by Chance (1968). Between 7 March, and 23 May, 1968, he took biweekly plankton tows of the largest quarry pond south of Ashmore, Illinois, sometimes called "Lake Ashmore." The 22 collections were taken by a No. 12 plankton net which was towed for a 200-meter distance behind a row boat. Qualitative examination of these collections revealed 19 genera of Rotifera, eight genera of Cladocera, three genera of Copepoda, and Ostracoda. McCoy (1969) using the same quarry pond, conducted a qualitative, 48-hour study of the zooplankton in the upper .5 meters between 12 and 14 July, 1968. He also used the technique of towing a No. 12 net behind a row boat. His results showed 12 genera of Rotifera, six genera of Cladocera, two genera of Copepoda, and no mention of Ostracoda.

As a portion of an overall, biological survey of the streams of Coles County, Durham and Whitley (1971) studied

194 plankton collections from 77 sites on the 20 streams within the county. These collections were made by straining 30 liters of water through a No. 12 plankton net and analyzed by use of a Sedgwick-Rafter cell, counting 30 fields. From these collections four genera of Rotifera, four genera of Cladocera, three genera of Copepoda, and no mention of Ostracoda were found in the streams of Coles County, between 1967 and 1970. Included in this study were 14 plankton collections made from Polecat Creek at 10 different sites, four of which were downstream from Lake Ashmore. This portion of the plankton results yielded two genera of Copepoda, one genus of Rotifera, and the absence of Cladocera and Ostracoda.

Ecology of lotic plankton:

The major physical difference between a lentic environment (lakes and ponds) and a lotic environment (rivers and streams) is the presence, in the latter, of a current. Consequently, the nature of the current has a great deal of influence upon the production and composition of the plankton community of a stream.

Phytoplankton research by Schröder (1899, cited by Reinhard, 1931) produced the theory that the quantity of plankton in a river is in inverse proportion to the slope of the river. In 1931, Reinhard refined this theory to state that if all other variables are kept constant, the plankton production of a stream is proportional to the age of the water and inversely proportional to its velocity.

Kofoid (1903, 1908) refered to the "age of the water" as an important factor in the production of stream plankton. He stated that waters of young streams contain little plankton, but if the same water is placed in an impoundment for 10 to 30 days, it will develop an abundant plankton crop. Coker (1929) found that the planktonic Crustacea of the Mississippi River increased as it approached the impoundment created by the Keokuk dam. Forbes (1905) noted that the more abundant plankton of permanent water in shallow lakes can enrich the plankton of a stream by its outflow. Eddy (1934) determined from observations of water of different ages that, all other factors being favorable, a few plankton organisms usually appear in the water of streams six to 10 days from its source, while abundant plankton appears in water 20 days or more from its source.

Velocity is high in young streams, causing more turbidity which subsequently moves the point of plankton production downstream (Eddy, 1934). When this water has been impounded in a reservoir or retained in the channel for the requisite time necessary for breeding, phytoplankton develops first, and then zooplankton (Kofoid, 1903).

The production of plankton tends to be less in short streams with relatively swift currents than in long streams with slow currents. Flood water and short tributaries dilute it and falling water concentrates it (Kofoid, 1905). While studying the upper Mississippi River, Galsoff (1924) noted that every rise of the water level and the accompanying increase in velocity was followed by a characteristic decrease in the plankton population, which had been washed away. During such rises in water level in the upper Mississippi River the plankton was replaced almost completely by detritus and silt.

Another feature causing a downstream plankton decrease is the destruction of organisms by the grinding action of turbulent waters. The severity of this action on the stream plankton varies widely with current velocity, the nature of the bottom, and the morphology of the plankton organism. Injury and mortality may be very high at times of flood (Welch, 1952). In the Mississippi River, Galsoff (1924) noted that the water below the Rock Island Rapids carried only about 40 percent as much plankton as that above the rapids. It was assumed that the plankters were destroyed not directly by the turbulent water itself, but by the collision with suspended sand grains and by the impact against the substrate. Kofoid (1908) described how the large copepod, *Diaptomus pallidus*, can be affected by the increased silt load of flood waters. "The long antennae and great development of the features of the caudal stylets afford a large area for the attachment of silt and debris of flood waters, and facilitate the destruction or removal from the plankton more quickly than in the case of other Entomostraca in which these processes are less developed as in *Cyclops* or *Bosmina*."

Kofoid (1903) observed that streams with great velocity usually have more phytoplankters than zooplankters and concluded that swift currents prevent the zooplankters from feeding, but does not greatly affect the assimilation processes of the phytoplankton. Galsoff (1924) cites this difference in response to current velocity as the reason why algae compose the larger part of stream plankton.

Eddy (1934) has shown that fresh-water plankton communities are comparable in certain respects to organisms of terrestrial communities. Both types of communities, when mature, have some species which are conspicuous and abundant, often termed "predominants." A plankton or a terrestrial community can reach a "climax" stage of development. In terrestrial communities this development comes about by a gradual replacement process called "succession." The development of stream plankton communities differs from that of terrestrial communities in that it is a steady "progression" rather than a succession. In the course of a stream, the plankton begins to appear as a very scanty community in the headwaters. As the water flows downstream, this community continues to develop, adding species, which reproduce, until eventually it approaches that of a "stable-stream community" in which there is no change in most of the predominant species from year to year.

The plankton community of a stream is very similar to that of a lake in that they show a common ecological relationship by the possession of common predominant species. The difference between the stream and lake communities lies in the "climax" community towards which each develops. The climax community of a stream is that of an ecologically stable stream community, while that of a lake develops towards a terrestrial climax (Eddy, 1934).

The origin of the plankton found in streams is difficult to designate. Kofoid (1908) determined that reproduction occurring in the main channel and its tributaries is not the main source of plankton production in the Illinois River. He found that most of the river plankton has its origin in the impoundments of reservoirs and backwaters where the environment is more stable. Thus, river plankton can be called "polymixic" or resulting from the mingling of plankton from various sources of the drainage basin. Consequently, the quantity and quality of the stream plankton will vary accordingly to the environmental fluctuations felt by the various sites of plankton origin. Butcher (1932) found that almost all phytoplankton organisms of a stream can be located, at one time or another, on the river bed or among submerged and littoral macrophytes. Occassionally, some of these individual plankters are washed free, thus adding them to the stream. It is very probable that this same mechanism also applies to some members of the Crustacea and Rotifera as a source of stream plankton addition.

Reinhard (1931) studied the influence of plankton additions to the Mississippi River from sizeable tributaries and discovered an equilibrium phenomena in the main stream.

The sharp rise in the plankton population in the Mississippi, caused by the additions from large tributaries, quickly declined downstream, finally dropping back to the same level which had characterized the river plankton prior to receiving the tributary supplement. Apparently, the main stream can reestablish a state of equilibrium altered by a tributary. Large tributaries can increase the population, food, and "living space" of the main stream. The increase in space is a permanent addition, while the increase in food supply is merely temporary. At first, supersaturation of the plankton population is bound to occur. Eventually, however, the food addition will be utilized and the return of competition will reduce the population back to an equilibrium as it moves downstream from the tributary.

Eddy (1934) said that the plankton element of mature streams may be reproduced by impounding the waters of immature streams so that they age under more stable conditions. Thus, the waters of a small stream containing little plankton can produce an abundant crop by the temporary halting of its waters. Several researchers have investigated the fate of this now abundant crop of plankton when it is reintroduced back into the same immature stream.

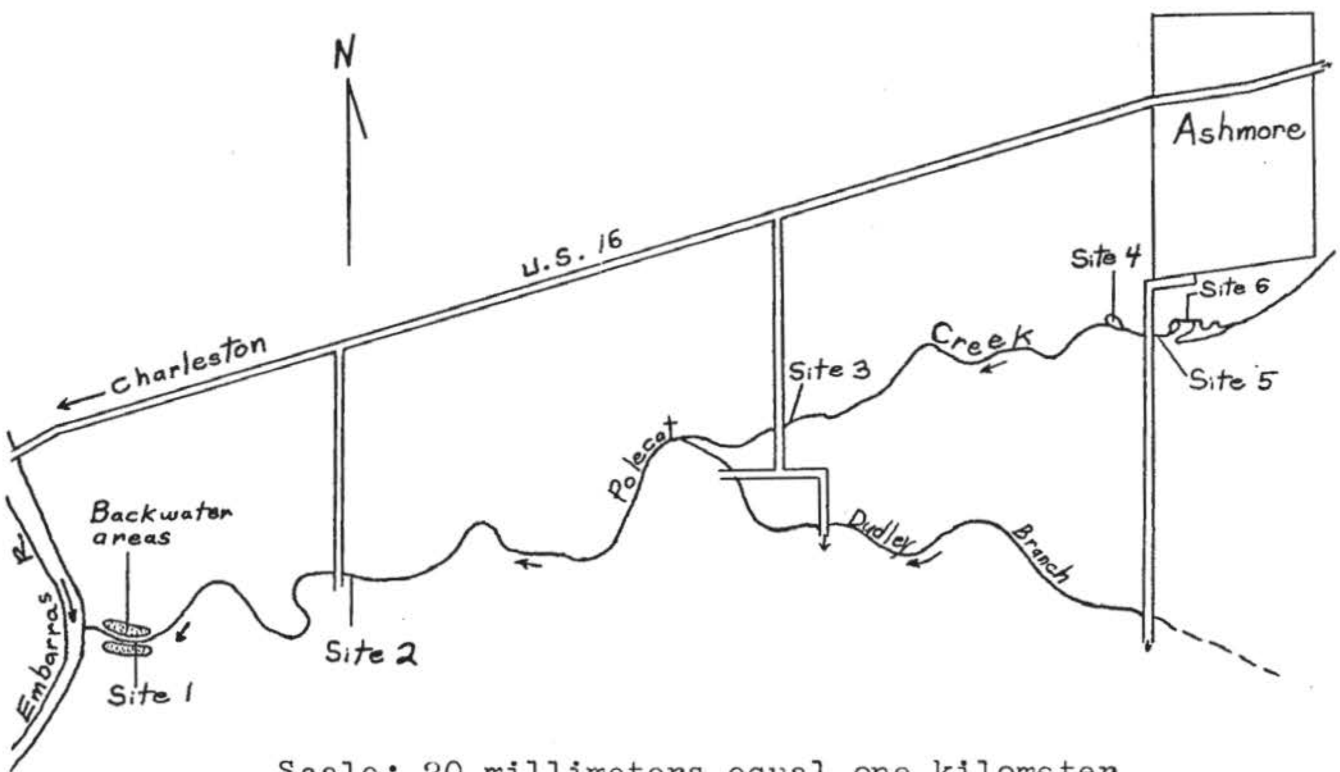
Woltereck (1908), Andre' (1926), Chandler (1939), Brook and Woodward (1956), and Ruttner (1964) show that plankton tends to avoid the outlet areas of lakes. Woltereck (1908) and Andre' (1926) as cited by Hutchison (1967) showed that the water leaving a lake contained less plankton, particulary zooplankton, than the open waters of the lake. Chandler (1939) took volumetric plankton samples of the open water of Base Line Lake, Michigan, and of the water of its outlet. He found that only 55 percent of the total Rotifera and Crustacea entered the outlet and exited the lake. Brook and Woodward (1956) compared the numbers of organisms in surface samples taken near the point of exit of a lake outlet to those taken in the discharged water. They found that Cladocera and Copepoda do actually avoid being washed out of the lake. Ruttner (1964) said that the entire plankton of a lake is not effected by the inflow-outflow of a stream. The good swimmers, especially the Crustacea, are frequently able to avoid the outlet and so escape being carried out of the lake, perhaps exhibiting a negative rheotropism. It is suggested that such factors as the shape of the lake basin, size of the outlet, stratification (Chandler, 1939), and filtration by littoral plants (particularly near the outlet) (Hutchison, 1967) are important for determining the differences between lake and stream plankton.

Allen (1920), Chandler (1937), Eddy (1932, 1934), Reif (1939), Beach (1960), Cushing (1964), and Ruttner (1964) describe a progressive downstream decrease of the plankton entering the outlet stream of an impoundment. Allen (1920) observed that small streams with swift currents, which drain lakes and ponds containing abundant plankton, show a gradual decrease downstream of this newly acquired plankton addition. Chandler (1937) did some very informative studies of the fate of lake plankton entering a small stream. He concluded that the quantitative decrease of lake plankton entering a stream is related to the amount of aquatic vegetation, water level, and volume of lake plankton entering the stream. He demonstrated that objects occurring in streams collect plankters on their exposed surfaces. It was determined that heavy mats of the alga, *Lyngbya*, and accumulations of debris around macrophytes, just below the lake outlet, dramatically removed a large percentage of the plankton which would have otherwise become part of the stream biota. Temperature, pollution, dilution from tributaries, current, and a change in chemical conditions were cited as factors not causing a downstream decrease of lake plankton in the streams investigated.

It has also been demonstrated that the origin of the rapid decrease of lake plankton in a stream outlet is associated with the biotal film (Bewuchs) of the stream bed. Ruttner (1964) found a nanoplankton decrease phenomenon in the outflowing streams of Lunzer Obersee. It was suggested that the algal growth on the rocks of the stream bed could retain the suspended nanoplankton at this substrate interface where there is scarcely any current.

Reif (1939) investigated the downstream decrease of lake plankton in three very short streams in Minnesota. He determined that stream plankton could be reduced by siltation, dilution, destruction, and predation by *Hydropsyche* and possibly Chironomidae and Plecoptera naiads. Also, the plankton can be carried further during periods of high water, thus showing less qualitative decrease over a given distance than at low water. The passive and less fragile zooplankton tend to travel further than those which are more delicate and active. He determined that plankton, which is constantly supplied by a lake, travels a distance determined by time and the carrying power of the current, minus the effects of siltation, dilution, and destruction.

Eddy (1932) monitored the effects of the Lake Decatur impoundment upon the plankton of the lower Sangamon River and noted that many forms which apparently had their origin in the lake showed a decided decrease below Decatur. The combined Crustacea and Rotifera portion of these decreasing forms totalled eight for the June collections (Codonella cratera, Brachionus angularis, Polyarthra trigla, Kertella cochlearis, Moina affinis, Daphnia longispina, Bosmina longirostris, and Cyclops bicuspidatus) and nine for the July collection (Codonella cratera, three species of Brachionus, Filinia, Asplanchna, Polyarthra, Synchaeta, Pedalia, and Trichocera). The September collections showed 14 species of Rotifera which were not present in the lake but appeared downstream from the dam, some showing a steady increase in abundance. The decreases observed in June and July might have been caused by insufficient local (stream) development to counterbalance the dilution from tributaries. The September tendency for rotifers to increase downstream was most likely due to the low water conditions of the stream which made it more "lake-like" and therefore more favorable for local development of plankton. In general, it was concluded that even though it is possible for an immature stream to carry part of the acquired lake plankton for a week or more, the presence of this plankton in the lower course of the stream usually represents various stages of senesence of the biota as it moves away from its source. Wiebe (1927), in a like manner, discussed the difficulty in determining whether an organism was produced where it was taken or whether it was carried there by current.



Scale: 20 millimeters equal one kilometer

Fig. 1. Location of sampling sites 1 - 6 used in the zooplankton study of the lower 7.6 kilometers of Polecat Creek, Coles County, Illinois, from February 21 to June 13, 1975. Also indicated are the locations of the three quarry ponds near the town of Ashmore and the backwater areas adjacent to Site 1. Map adopted from the Triennal Atlas and Plat Book, Coles County, Illinois, 1973, Rockford Map Publ., Inc., Rockford, Il.